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GRAPE GROWING IN CALIFORNIA

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CONTENTS

GRAPE GROWING IN CALIFORNIA

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THE CULTIVATED GRAPES of California are mostly of the kind grown in the countries bordering the Mediterranean and referred to as "European" grapes. They are derived from one wild species—*Vitis vinifera*—native to western Asia. Of the cultivated vines in the world more than 90 per cent are pure vinifera. Most of the important varieties cultivated in the remainder of the United States, except Arizona, have been derived from American wild vines or from crosses between them and *V. vinifera*. These are properly called "American" grapes.

California has a half-million acres of vineyards, constituting about 80 per cent of the total grape acreage of the United States, but only 3 per cent of the total world acreage. The state produces about 2 per cent of the world's wine, 15 per cent of the world's table grapes, and 30 per cent of the world's raisins.

TYPES OF GRAPES AND THEIR USES

Grapes are conveniently grouped into four general classes according to the purposes for which they are used: (1) wine grapes, (2) table grapes, (3) raisin grapes, and (4) sweet (unfermented) juice grapes. Any variety can be fermented into a kind of wine, can be eaten fresh, dried into raisins, or made into sweet grape juice; but each variety is usually better suited to one of these purposes than to the others.

WINE GRAPES

Briefly, a wine grape may be defined as a variety known to be capable of producing satisfactory wine in some locality. Dry wines require grapes of high acidity and moderate sugar content; sweet wines, high sugar and moderately low acidity; in addition, quality wines require special characteristics, such as those of Riesling, Semillon, Cabernet, and Muscat. The quality of the wine depends not only on the variety but also on the environment; the best dry-wine grapes are produced in the cooler districts, the best sweet-wine grapes ordinarily in the warmer. Although the texture of the skin and the pulp does not affect the quality of the wine, thick skin and firm pulp may reduce the juice yield, and thin skin and very soft pulp may increase the care required in harvesting and transporting the fresh grapes. Most good wine grapes are of small or medium size. The best are usually light or moderate bearers.

TABLE GRAPES

Grapes to be used fresh, either for food or for decoration, are commonly called table grapes. They must be attractive in appearance; must possess good eating, carrying, and keeping qualities; and—to be widely used—must be produced and sold at a relatively low cost.

The tastes of the consumer vary in different markets. Large size, brilliant color, and unusual form are generally appreciated. In American markets, seedlessness is an advantage. Where table grapes must be shipped long distances or stored for considerable periods, firmness of pulp, toughness of skin,

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and adherence to the stems are important. Except for the Thompson Seedless (Sultanina), which owes its popularity primarily to its seedless character, all the important table varieties grown in California—Flame Tokay, Emperor, Malaga, Red Malaga (Molinera), and Ribier (Alphonse Lavallée)—have attained their prominence because they possess a better combination of attractive appearance, good eating quality, resistance to injury in handling, and good keeping in storage than any other varieties sufficiently tested under the general cultural and marketing conditions of the state.

The particular combination of characteristics that will render a table grape attractive and successful depends not only upon the variety but also upon the soil and the climate. For this reason, certain varieties can be grown profitably only in limited areas. Thus the Flame Tokay does best near Lodi; the Emperor on the east side of the San Joaquin Valley in Tulare and Fresno counties.

To attain the quality of fruit and the quantity of crop necessary for success, table grapes in general require a warm climate and a favorable, but not necessarily highly fertile, soil. Very early varieties are most profitable in the warmest and earliest localities. In the later localities the midseason and late varieties, more attractive in appearance and better in shipping and keeping quality, are preferred.

RAISIN GRAPES

Raisins are essentially dried grapes; yet different varieties and different methods of drying may yield very unlike products, so much so that in other countries a distinction is often made between raisins and "dried grapes." Desirable characters in a variety to be used for raisins include: (1) soft texture of the dried product; (2) lack of tendency of the raisins to stick together when stored; (3) seedlessness; (4) earliness of ripening; (5) marked, pleasing flavor of the raisins; (6) ease of drying; (7) large or very small size; and (8) high productivity of the vines. Of the thousands of grape varieties known, only three—Thompson Seedless, Muscat of Alexandria, and Black Corinth (Zante Currant)—are used to make most of the world's raisins. The Thompson Seedless and Muscat of Alexandria are widely grown in the San Joaquin Valley of California, whereas the Black Corinth is grown principally in Greece and Australia and is of only minor importance here.

UNFERMENTED-JUICE GRAPES

For the making of sweet, unfermented grape juice it is necessary, or at least desirable, for the grapes to retain their natural fresh-fruit flavor throughout the processing required to clarify and preserve the juice. In America the juice is most commonly pasteurized after it has been clarified. Most vinifera varieties when pasteurized by the usual method lose their fresh flavor and acquire an unpleasant cooked taste. Even the strong Muscat flavor changes from that of the fresh grape to one suggestive of Muscat raisins. The strong, "foxy" flavor of certain American varieties, particularly the Concord, comes through the usual processing and pasteurization almost unchanged; hence most of the grape juice made in America is of Concord grapes alone or of Concord blended with other varieties. In certain parts of Europe, where the juice is sterilized by close filtration only, then bottled under sterile conditions, vinifera varieties are commonly used.

CLIMATIC REQUIREMENTS FOR GRAPE GROWING

Most vinifera grapes need long, warm-to-hot, dry summers and cool winters for their best development. They are not adapted to humid summers, whether temperate or tropical, because of their susceptibility to certain fungus diseases that flourish under such conditions. Neither will they withstand intense winter cold (below 0° F) without protection. Frosts occurring after vine growth starts in the spring may kill most of the fruitful shoots and disastrously reduce the crop. To mature the fruit, a long growing season is needed. Rain during the winter is desirable, though deficiencies can be made up by irrigation. Rains early in the growing season make disease control difficult but are otherwise not detrimental to growth. Rains or cold cloudy weather during the blooming period, however, may cause poor setting of the berries. Rains during the ripening and harvesting periods result in much damage through rotting of the fruit. In relatively cool regions a higher humidity can be tolerated than in warmer regions. Where raisins are to be made by natural sun-drying, a month of clear, warm, rainless weather after the grapes are ripe is essential.

American grapes—Concord and others—withstand humid summers and cold winters better than pure vinifera varieties. They do better in regions of moderate summer humidity than in the very dry, semiarid climate of the interior valleys of California. Rare, indeed, are the grapes that will endure high humidity coupled with high temperatures, a condition common in the tropics.

TEMPERATURE REQUIREMENTS FOR GRAPE GROWING

Vinifera grapes start growth in the spring soon after the daily mean[2] temperature reaches 50° F. A winter rest period of 2 or 3 months, during which the average daily mean temperature is below 50°, with some freezing but with no temperatures below 0°, is desirable. Daily mean temperatures of at least 65° are necessary for proper development and ripening of most varieties; and somewhat higher temperatures, 70° to 85°, are needed for some. The time elapsing from blooming to ripening is largely determined for each variety by the effective-heat summation, which, for a given place, is usually calculated by subtracting 50° from the mean temperature for each day[3] and adding together, algebraically, the quantities thus obtained. The result is expressed as degree-days. The earliest varieties require about 1,600 degree-days; the latest, at least 3,500. Beginning the summation of heat at the time of full bloom, Thompson Seedless will be ripe for table use (18° Balling) when the temperature summation above 50° reaches 2,000 degree-days. This variety will be fully ripe for raisins (25° Balling) when the summation reaches 3,000. Similarly, Tokay will be ripe for table use at about 2,300 and Emperor at about 3,200 degree-days.

[2] Average of the maximum and minimum temperatures for the day. These can be obtained for many locations from *Summary of the Climatological Data for the United States, by Sections*, published by the Weather Bureau of the U. S. Department of Agriculture, Washington, D. C.

[3] Where whole months are involved, the same result is obtained by multiplying the monthly mean temperature, less 50° F, by the number of days in the month.

TEMPERATURE REGIONS

Temperature, especially during the ripening period, also strikingly affects the chemical composition of the grapes—hence their value for various uses. On the basis of temperature, or more specifically the summation of heat as degree-days above 50° F for the arbitrary period April 1 to October 31, any grape-producing area of California falls into one or another of five convenient temperature groups or regions. These groups, with representative locations, are as follows:

1. Cool regions (less than 2,500 degree-days of heat from April 1 to October 31), as at Napa, Oakville, Hollister, Mission San Jose, Saratoga, Bonny Doon, Guerneville, Santa Rosa, and Sonoma.
2. Moderately cool regions (2,501 to 3,000 degree-days of heat from April 1 to October 31), as at Rutherford, St. Helena, Glen Ellen, Healdsburg, San Jose, Los Gatos, Soledad, and Santa Barbara.
3. Warm regions (3,001 to 3,500 degree-days of heat from April 1 to October 31), as at Calistoga, Ukiah, Hopland, Cloverdale, Livermore, Paso Robles, and Alpine (in San Diego County).
4. Moderately hot regions (3,501 to 4,000 degree-days of heat from April 1 to October 31), as at Davis, Sacramento, Lodi, Manteca, Modesto, Ojai, Ontario, and Escondido.
5. Hot regions (more than 4,000 degree-days of heat from April 1 to October 31), as at Livingston, Merced, Madera, Fresno, Visalia, Delano, Bakersfield, Chico, Red Bluff, Redding, and San Bernardino.

The cool and moderately cool regions (1 and 2) produce the best table wines; the warm regions (3) the best natural sweet wines; and the moderately hot and hot regions (4 and 5) the best dessert wines, together with the commercial table and raisin grapes.

GEOGRAPHICAL GRAPE-GROWING REGIONS OF CALIFORNIA

The variations in climate caused by various physiographical factors make it possible to divide the grape-growing area of California into several geographic regions distinct at their centers, but intergrading from one to the other: (1) the north coast, (2) the south coast, (3) the Sacramento Valley, (4) the intermediate central valley region, (5) the San Joaquin Valley, and (6) the hot desert. (See map, fig. 1.)

THE NORTH COAST REGION

The north coast region comprises the valleys between the coast ranges that roughly parallel the ocean shore, and also the lower slopes of these ranges. The largest vineyard areas are found in Mendocino, Sonoma, Napa, Alameda, and Santa Clara counties. Practically no grapes are grown close to the ocean, where coastal fogs and low average temperatures prevail during the summer.

Temperatures increase as one proceeds up the valleys, away from the ocean. Localities near the ocean, but protected from its immediate influence by intervening hills and having less than 2,500 degree-days of accumulated heat above 50° F from April 1 to October 31, are the coolest grape-growing areas of the

state. The upper reaches of the larger valleys are warm (3,000 to 3,500 degree-days April 1 to October 31). All gradations between these extremes are present, sometimes within a relatively few miles' distance. Rainfall varies from less than 10 inches at Soledad in Monterey County and 14 inches in the

Fig. 1.—The grape-growing regions of California. (From Ext. Cir. 30.)

Livermore Valley of Alameda County to over 40 inches in parts of Sonoma and Mendocino counties. Irrigation is not common, although it is profitable in some areas where water is available at low cost.

The north coast region produces grapes which are primarily used for table wines. The soils and climate are well suited to dry-wine and natural-sweet-wine grapes, but one must choose the varieties carefully in order to utilize the natural advantages of each locality. In general, heavy-yielding sorts for producing wines of standard quality should be planted on the fertile soils in the warmer areas. On the other hand, the varieties capable of producing fine wines

should be planted in the moderately cool and the cool areas, where they attain their highest quality for the making of fine table wines.

No commercial raisins are produced in this region, and table grapes are grown only for home use or for local markets.

THE SOUTH COAST REGION

In southern California, at present, the main grape-growing area lies around the junction of Los Angeles, Riverside, and San Bernardino counties. At one time Orange County and the westerly half of Los Angeles County contained more vines than all the rest of the state. Now, in most of this area, the grapes have been replaced by citrus fruits, walnuts, vegetable crops, and suburban homesites.

Although a few table grapes are produced for the local markets, the main crop is wine grapes which are used for dessert and table wines. The climate is moderately hot, closely resembling that of the intermediate central valley region.

THE SACRAMENTO VALLEY

Northern California contains a great interior valley more than 400 miles long and from 50 to 75 miles wide, stretching from Redding to Bakersfield. The northerly part of this great body of agricultural land is called the Sacramento Valley; the southerly part is the San Joaquin Valley; the middle part, from Sacramento to Modesto, may be conveniently called the intermediate central valley region. This great valley with its three parts is protected on the east by the Sierra Nevada, from the wintry blasts of the north by the Siskiyous, and from the cool summer fogs of the ocean by the Coast Range running parallel to the shore.

Northward through the Sacramento Valley the influence of the sea breezes gradually diminishes, while the seasonal summation of heat increases, reaching about 4,580 degree-days (April 1 to October 31) at Chico, or nearly the same as at Fresno. The rainfall also increases from 18 inches at Sacramento to about 24 inches at Chico and 37 inches at Redding. Less irrigation is needed than in the San Joaquin Valley. Grape growing in this region has been less developed than farther south. Because of more frequent and earlier autumn rains, the hazard of sun-drying raisins is greater than in the San Joaquin Valley. Dessert-wine grapes, however, do very well; and as the markets for California wines expand, the Sacramento Valley may rival the San Joaquin as a dessert-wine-producing region. It is too hot for most table-wine grapes. The occasional strong north winds make most of the west side of the valley unsuited to table grapes, although some of excellent quality are grown in sheltered locations on the east side and at the lower end of the valley.

THE INTERMEDIATE CENTRAL VALLEY REGION

This region, the coolest of the great interior valleys, has a moderate rainfall of 12 to 18 inches, a moderate effective temperature summation, at Lodi, of about 3,530 degree-days from April 1 to October 31. It is kept cooler than the rest of the great central valley by the sea breezes that pass through the gap in the coast ranges near the Golden Gate. It is in this region that the brilliant Flame Tokay table grape most nearly reaches perfection. Here also are large

areas of vineyards with a heavy production of wine grapes, from which standard table and dessert wines are made.

THE SAN JOAQUIN VALLEY

Southward through the San Joaquin Valley the average temperature increases, becoming more favorable for varieties that need abundant heat. Near the center, at Fresno, the effective seasonal summation of heat (April 1 to October 31) is about 4,690 degree-days. The annual rainfall, on the other hand, decreases gradually from about 11 inches at Modesto to 6 inches at Bakersfield. In all parts of the valley, therefore, irrigation is necessary for the best results. This region produces much of the world's raisin crop.

With the exception of the Flame Tokay, which is produced chiefly in the intermediate central valley region, and the very early grapes of the hot desert, most of California's table grapes come from the San Joaquin Valley. They are grown mainly in the eastern half of the valley in Fresno, Tulare, and Kern counties.

The San Joaquin Valley also yields large quantities of wine grapes which, high in sugar and low in acid, are well suited for dessert but not for table wines.

THE HOT DESERT REGION

The Imperial and Coachella valleys, in the Colorado Desert, are no longer barren since the bringing of water from the Colorado River and the installation of wells and pumps in certain areas not supplied by the river. This, the hottest grape-growing region of California, produces the earliest grapes, principally Thompson Seedless. Raisins are not produced, because the early table grapes ripening in June and early July are more profitable; yields are low, and costs of production high. Because of their earliness, however, the table grapes of the hot desert are prominent in the viticultural industry of the state.

SOILS FOR VINEYARDS

Grapes are adapted to a wide range of soils. In nearly every grape-growing district one finds a preference for certain soil types; and yet in listing all the soils used for growing the various kinds of grapes in the many individual grape-growing regions of the world, one finds a range from gravelly sands to clay loams, from shallow to very deep soil, and from low to high fertility. Very heavy clays, very shallow soils, poorly drained soils, and soils containing relatively high concentrations of salts of the alkali metals or of boron, or of other toxic substances, are avoided. The deeper and more fertile soils usually produce the heaviest crops and are generally preferred for raisins, common wine-grape varieties, and some table grapes. Certain wine and table-grape varieties attain higher quality when grown on soils of limited depth and fertility.

ESTABLISHING THE VINEYARD

A favorable combination of locality, variety, cultural methods, and proper utilization of the crop is essential to success. A prospective grower may start in one of two ways: (1) He may have a tract of land on which he wishes to grow grapes. Then he must determine the type of grapes, the varieties most likely to succeed, and, finally, the cultural methods applicable. (2) He may

wish to grow a certain type of grape or perhaps even a certain variety. If so, he should choose the location and adopt the cultural practices apparently best suited to his purposes. Experience is the best teacher. Lacking experience himself, he may consult his local county farm advisor or agricultural commissioner, other successful growers, and available literature. Publications of recent date are preferable, since recommendations change as more information is made available. To plant a variety already successful in the district is usually the safest practice. The planting of a new variety in an old grape-growing district, or of any variety in a new district must be considered experimental and should usually be done at first only on a small scale.

Important specific conditions to be considered are climatic factors, such as temperatures, winds, frosts, and rainfall; topography, depth, texture, and fertility of the soil; availability and cost of water for irrigation; roads and distance to winery, packing shed, or shipping point; and sources of labor and supplies.

PREPARATION OF THE SOIL

Before planting, one should clear the land of trees, stumps, large stones, noxious weeds, and rodent pests. If irrigation is possible, the land should be leveled or graded properly. It should then be well plowed 8 or 10 inches deep; and if a plow sole or other hard substratum that can be economically broken up is present, subsoiling is advisable. The soil surface need not be pulverized and compacted, as for a seedbed, but should be freed from large clods that might interfere with the use of the planting line and with the actual planting.

PLANTING STOCK

One-year-old rootings of the desired fruiting variety should generally be used in planting a vineyard in any location, except where the presence of phylloxera or a heavy infestation of nematodes requires the use of special resistant rootstocks.[4] Nearly the whole north coast region and parts of the Sacramento and San Joaquin valleys and of the intermediate central valley region are infested with phylloxera. Within such areas one should plant only grafted vines, or rootings of rootstocks resistant to phylloxera which are later to be budded or grafted to the desired fruiting variety.

PLANTING DISTANCE AND ARRANGEMENT

Wide spacing of vines, particularly in one direction, makes for ease and economy of operation. The cost of cultivation, for example, is determined more by the number and length of rows than by the actual acreage in the vineyard. Harvesting labor and costs are materially reduced if the grapes can be hauled out from between the rows rather than be carried out to the avenues. The cost of brush disposal is nominal if the brush can be disked or shredded, but becomes a considerable item when the material must be carried or hauled away. Power-dusting equipment can be used only if the rows are far enough apart to permit movement of the machine through the vineyard. The initial costs—of vines, planting, stakes, and training—are directly proportional to the number of vines, not to the acreage. Table 1 shows the number of rows and the vines per row in a square 10-acre planting with the various common spacings; the table also shows the number of vines per acre.

[4] See p. 67.

Moderately close planting, on the other hand, usually produces larger crops while the vines are young. Unless the wide spacing is carried to extremes, the crop after the vines are mature is about the same.

The most desirable spacing, therefore, is the widest that one can have without reducing the crop in the mature vineyard. In general, a closer planting is used for small-growing varieties, cool regions, and poor soils; wider spacing for large-growing varieties, warm regions, and fertile soils. In the past, in California, spacings of 7 × 7 feet and 8 × 8 feet have been customary in the cooler regions and 10 × 10 feet or 8 × 12 feet in the hotter ones.

TABLE 1

DISTANCE BETWEEN AVENUES, NUMBER OF ROWS, AND VINES PER ROW IN A SQUARE 10-ACRE PLANTING WITH VARIOUS SPACINGS; AND NUMBER OF VINES PER ACRE

Spacing	Approximate distance between avenues	Number of rows* in a square 10 acres	Vines per row in a square 10 acres	Number of vines per acre
feet	*feet*			
7 × 7	200	89	87	774
8 × 8	200	78	78	608
7 × 9	200	70	87	609
6 × 10	300	63	102	643
7 × 10	300	63	86	542
8 × 10	300	63	76	479
8 × 12	620	53	78	413

* Avenues about 20 feet wide are allowed for on each side of the 10-acre block.

Square planting—the rows and the vines in the row the same distance apart—permits cross-cultivation, an advantage where small tools are used. Avenue arrangement—the rows farther apart than the vines in the row—permits the use of large equipment in one direction. Special tools, such as the Kirpy (French) plows, eliminate the need to cross the vineyard in cultivation. Economical tractor-powered cultivation, power dusting, and hauling the grapes out of the rows require 10 feet or wider spacing of the rows. Since the advantages of the avenue arrangement seem far to outweigh the disadvantages, such a pattern is recommended for all new vineyards.

For small- or medium-growing trellised varieties—Cabernet Sauvignon, the Rieslings, and the Pinots—spacings of 6 × 10 feet or 6 × 12 feet are recommended; for very small head-pruned vines 7 × 9 feet, or 7 × 10 feet; medium-sized head-pruned vines, 8 × 10 feet; large vines, head-pruned or trellised, 8 × 12 feet.

LAYING OUT THE VINEYARD

In large vineyards—40 acres or more—surveying instruments are convenient for dividing the area accurately into blocks of the desired size. The position of each row may be located with the surveyor's chain or with a special "row chain" made by melting buttons of solder on a no. 11 smooth galvanized wire at the distance the rows are to be spaced.[5] The individual vines in each

[5] A soldering flux of hydrochloric acid and zinc chloride may be used to make the solder stick to the wire.

row are nearly always located by using a planting line, made as described for the row chain except that the solder buttons are spaced according to the spacing distance of the vines in the row. The positions of the vines are marked by driving temporary planting pegs, $1 \times 1 \times 12$ inches, or permanent stakes at each button on the planting line. Regularity in lining up the vines and stakes and in planting the vines is necessary for economical handling of the vineyard later.

PLANTING THE VINEYARD

The rootings, or grafted vines, are pruned before the planting; the tops are cut back to a single good spur of one or two buds. For convenience in planting, the roots are shortened to 3 or 4 inches. All roots within 8 inches of the top of the pruned vine are removed entirely.

The vines must be carefully protected from drying out in all handling operations, from their removal from the nursery to their planting in the vineyard. When stored they should be heeled-in (partially or completely buried) in moist sand or soil in a cool place. While being moved from the storage place to the vineyard they must be well covered with moist sacks or canvas or, better still, hauled in tubs containing 2 or 3 inches of water. The planters carry the vines in planting cans (often made from 5-gallon paint buckets or 5-gallon oil cans). Two or 3 inches of water in the planting cans will keep the roots wet.

The holes for the vines are all dug on the same side of the planting pegs or stakes. In digging the hole, one does not remove the peg, but digs so that the side or corner of the hole at the peg slopes away from the peg 1 or 2 inches distant at the bottom. The hole should be slightly deeper than the vine is long. Then the vine is dropped into the hole with the top close to the peg; the hole is partly filled—one half or two thirds of its depth—with moist top soil; the vine is raised to the proper height and *the soil solidly packed* about the roots with the feet; the hole is filled almost completely and again the soil is packed firmly; then the hole is completely filled and the top of the vine covered, leaving the soil over the top well pulverized but loose. When the work is completed, the top of the vine should be exactly at the side of the peg, and the roots 1 or 2 inches away from the peg. All vines must slant in the *same direction,* so that the permanent stakes may be placed close to each vine on the side toward which the top slants without danger of breaking the vine. Rootings of the fruiting varieties are planted so that the two buds left after pruning are just above the general level of the ground. Bench-grafted vines are planted with the union about an inch above ground level. *Rootstock rootings that are to be budded or grafted in the field should have 2 or 3 inches of the main stem above ground level, in order that the graft union may be at or above the surface of the soil.* The tops of all are covered, to a depth of ½ to 2 inches, with a mound of loose soil to prevent drying before growth starts.

SUPPORTS FOR THE VINES

All vines should have some support, temporary or permanent. For head-pruned vines, stakes 4 to 6 feet long are sufficient. In six to ten years these may be removed, as the vines should then be self-supporting. For simple two-wire trellises, a 6-foot stake at each vine is sufficient, with two no. 11 or no. 12 smooth, galvanized fencing wires stretched along the row at 34 and 46 inches

from the ground (fig. 2). These supports are best put in place before the vineyard is planted, but for economy this work may be postponed until the winter immediately after the planting; it should not be delayed longer.

Often, for large-growing table-grape varieties, a "wide-top" trellis (fig. 3) is constructed by tying a crossarm (2 × 2 inches × 3 feet) to the top of each

Fig. 2.—A simple two-wire trellis in a young Thompson Seedless vineyard.

Fig. 3.—A sloping, wide-top trellis.

stake or each alternate stake and bracing the lower end to hold the crossarm at an angle of about 30° from the horizontal. The lower end is about 15 inches long; the upper end about 21 inches. One wire is usually fastened to the stakes just below the crossarms, and three wires are used on the crossarms. This type of trellis has certain advantages: (1) More fruiting wood may be retained at pruning. (2) Since the clusters are better distributed, more uniform exposure to light and air is obtained. (3) Thinning, girdling (on Thompson Seedless), and harvesting are facilitated.

PRUNING[6]

The following special terms are defined as they are commonly used in vineyard practice: *Pruning* consists in removing canes, shoots, leaves, and other vegetative parts of the vine. *Thinning* is the removal of flower clusters, immature clusters, or parts of clusters. (The removal of ripe fruit is *harvesting*.) *Training* consists chiefly in attaching the vine and its growth to various forms of support. *Shoots* are the current season's succulent top growth. *Canes* are matured shoots. The *trunk* is the undivided body of the vine. *Arms* are primary, secondary, or tertiary branches. A *spur* is the basal portion of a cane from one to four buds or nodes in length. A *fruit spur* is one that is intended primarily to bear fruit. *Renewal spurs* are intended to produce canes that may be used the next season for spurs or fruit canes; and *replacement spurs* are used to shorten or replace arms or branches; renewal and replacement spurs may or may not bear fruit. A *fruit cane* is the basal section of a cane, eight to fifteen buds long, used to produce the crop on cane-pruned vines; it is always removed at the following pruning. *Water-sprouts* are any shoots that arise on parts of the vine older than one year. *Suckers* are water-sprouts that arise below ground; the term is also frequently applied to water-sprouts from the trunk and main branches.

FUNCTIONS OF PRUNING

Pruning has three functions: (1) to aid in establishing and maintaining vines of a predetermined form or shape, one which will encourage productivity and which, at the same time, will save labor and facilitate cultivation, disease and pest control, thinning, harvesting, and other vineyard operations; (2) to distribute the bearing wood over the vine, between vines, and between years in accordance with the capacity of the spurs (or canes) and vines, in order to equalize production and secure large average crops of good fruit; and (3) to reduce or eliminate the cost of thinning in regulating the crop.

INFLUENCE OF PRUNING

Pruning, with reference to the removal of living parts, has two effects: it concentrates the activities of the vine into the parts left; and it diminishes the total capacity of the vine for growth and fruit bearing. Correct pruning consists in utilizing the first effect to the extent required while avoiding the second effect as much as possible.

Other things being equal, a heavily pruned vine will produce fewer leaves than one lightly pruned. It will also produce its maximum number of leaves and maximum area of foliage surface later in the season, so that the total annual work done by the leaves will be less. In consequence, smaller quantities of carbohydrates, such as sugar and starch, will be formed; and the amount available for the nourishment of roots, stem, shoots, flowers, and fruit will be less. This effect, unless the crop is controlled by thinning, is usually masked by the fact that the lightly pruned vine produces a very large crop; and, as the crop weakens the vine to an extent comparable with the effect of

[6] The principles and practices of pruning vines are more fully discussed in: Winkler, A. J. Pruning vinifera grapevines. California Agr. Ext. Cir. 89:1–56. Revised 1945.

pruning, the actual production of wood, foliage, and fruit by the lightly pruned vine, over a series of years, may be no more than that by the heavily pruned vine. If the crop is restricted by appropriate thinning, however, the lightly pruned vine will usually produce more crop and will grow better than the heavily pruned.

Fig. 4.—A mature head-pruned vine.

TIME OF PRUNING

The chief pruning is done while the vine is dormant, between leaf fall in the autumn and the starting of growth in the spring. The time of pruning within the dormant period has little or no influence on the vigor of growth or production of fruit the following season, if the vines are not frosted after growth starts. Very late pruning may, however, slightly delay the time when growth begins. By pruning when the upper buds on the canes have grown an inch or two, one may retard the starting of the lower buds (those left on the spurs) as much as a week or ten days, and these may escape damage if frost occurs within that period. Only very late pruning considerably affects the time of starting growth; in most regions, the differences caused by pruning at various dates between December 1 and March 1 are negligible.

Summer pruning, which includes disbudding, suckering, pinching, topping, and leaf removal, is used only for special purposes, as explained on pages 20 to 25.

SYSTEMS OF PRUNING

The various styles of pruning used in commercial vineyards in California may be grouped into three main classes or systems—namely, head, cane, and cordon.

Head Pruning.—In the head system the vine is given the form of a small, upright shrub. The mature vine consists of a vertical stem or trunk, 1 to 3 feet high, bearing at its summit a ring of arms or short branches. At the ends of these arms, at each winter pruning, are left spurs to produce the shoots that

Fig. 5.—A mature cane-pruned vine on a two-wire trellis.

will bear the next crop and furnish canes for the next year's spurs. Thus, this system consists of head training and spur pruning. The point or region where the trunk divides into, or bears, the arms is called the head (fig. 4).

The advantages of head pruning are simplicity of form, ease of training, and cheapness. The headed vine is the easiest type to establish, largely because the trunk is relatively short and upright. The cost of support is relatively low. During the developmental period, stakes are necessary; but after five to ten years, the trunks are rigid enough to be self-supporting. Cross-cultivation is possible, a feature that may be advantageous when the control of noxious weeds is a problem.

The disadvantages of head pruning lie chiefly in the depressing effect of severe pruning on the growth and productivity of the vines and in the massing of the fruit within a small area. When crop is controlled entirely by pruning, as with most head-pruned varieties, the pruning must be severe in order to prevent overbearing.

Head pruning suits most varieties that bear well on short spurs. It is used for most wine grapes, for the raisin Muscat, and for a few table varieties, notably the Tokay.

Cane Pruning.—In cane pruning, the vine is given a trunk similar in form to that in head pruning. The head of the vine differs in being fan-shaped in

the plane of the trellis. Only two arms on each side of the head are usually needed. At each annual pruning, after the vines are mature, fruit canes eight to fifteen buds (2 to 5 feet) in length are retained for producing the crop (fig. 5). The old fruit canes are removed each year. The production of canes for use the following year is left largely to the renewal spurs, usually two buds long and located near the base of each fruit cane.

Cane pruning is necessary for varieties, such as the Thompson Seedless, that have mostly unfruitful buds near the base of the canes. It also insures full crops with varieties that produce very small clusters, such as the Cabernet

Fig. 6.—A mature horizontal, bilateral, cordon-pruned vine. (From Ext. Cir. 89.)

Sauvignon, the Rieslings, and the Pinots. Combined with appropriate thinning to regulate crop, it offers other advantages: the fruit may be distributed over a large area; the tendency of certain varieties, like the Muscat of Alexandria and the Dattier, to produce shot berries and straggly clusters may be reduced; and, since there will be more clusters than are needed for a crop, the grower may eliminate the least desirable ones by thinning, and thus improve the average quality of the fruit.

The disadvantages of cane pruning are twofold: the tendency of most varieties to overbear, with consequent production of poor fruit, unless adequate thinning methods are employed; and the high cost of pruning and of supports—a trellis is usually necessary. For raisin and wine grapes the simple two-wire trellis is sufficient, but for fine table grapes a wide-topped trellis is better.

Cordon Pruning.—Cordon-pruned vines have no definite head. The trunk, which is much elongated either vertically or horizontally, bears arms at intervals of 8 to 12 inches over the greater part of its length. In California the horizontal bilateral form only is recommended. The trunk rises vertically to a point about 8 inches below the supporting wire of a trellis. At this point it divides into two equal branches, which rise to the wire in quarter circles and

extend in opposite directions along the wire to points halfway to the adjacent vines on either side. The bends should be smooth and regular; the horizontal portions straight. No shoots should be permitted on the bends of the mature vines. The bearing units are spurs on small arms located at regular intervals on the horizontal part of the branches. They should, wherever possible, be on the upper side of the branches or at least extend in an upward direction if they originate elsewhere (fig. 6).

The fruit on horizontal cordon-pruned vines is well distributed, with all clusters hanging at about the same distance from the ground—conditions favorable to uniform development and maturation of the fruit. Some varieties that require long spurs with head training bear fair crops on spurs of normal length when pruned by the cordon system.

The greater length of the trunk of the vines makes the cordon the most laborious and most expensive system to establish. Not only is more work required, but the labor employed must be more skilled, and a trellis or some other permanent support is essential.

In California cordon pruning is commonly used only with certain table-grape varieties, particularly Malaga, Red Malaga, Ribier, and Emperor. It should also be advantageous for the vigorous wine-grape varieties that produce very large clusters.

PRUNING OF BEARING VINES

Head Pruning of Bearing Vines.—On a mature vine, the number and length of spurs left the previous year, together with the size of the canes and the number of clusters produced during the current season, may be used as a guide. (The number of clusters produced may be learned by counting the stubs left when the clusters were cut off.) A vine that produced a good crop and has canes of normal size should be pruned to about the same number of spurs of similar length (as measured by the number of buds) as the year before. If the canes are abnormally large for the variety, indicating that the vines were very vigorous the previous summer, more spurs, or longer spurs, or both, should usually be left in order to utilize this capacity in the production of fruit. If, on the other hand, the canes appear weak—that is, small for the variety—fewer buds should be left. To reduce the number of buds, one may reduce the number of spurs retained or may cut the spurs shorter. Spurs retained from large or vigorous canes should carry more buds than those retained from small or weak canes.

The spurs should be so placed that the form of the vine is maintained or improved and the fruit uniformly distributed. Whenever possible, canes from near the base of last year's spurs should be used for the new spurs. The arms elongate from year to year. When an arm becomes too long it is shortened to a replacement spur made from a water-sprout or other suitably located cane.

Cane Pruning of Bearing Vines.—The renewal spurs left the previous season should have produced two good canes apiece. On an ideally shaped vine the uppermost cane on the spur would be used for the fruit cane, and the lower one cut back to two buds to form the new renewal spur. Wherever feasible, this practice should be followed. If, however, enough good canes cannot be obtained from the old renewal spurs, then canes arising near the base of

the old fruit canes, or even water-sprouts, may be used for the new fruit canes or renewal spurs.

The number of fruit canes needed varies from one to six, according to the size and total growth of the vine. The length of these canes depends upon their individual size: large ones may be left to a maximum length of fifteen buds; small ones should have proportionally fewer buds. If the crop is to be regulated by thinning, as with all table varieties when cane-pruned, a standard number and length of fruit canes may be adopted, and the crop on each regulated according to its vigor.

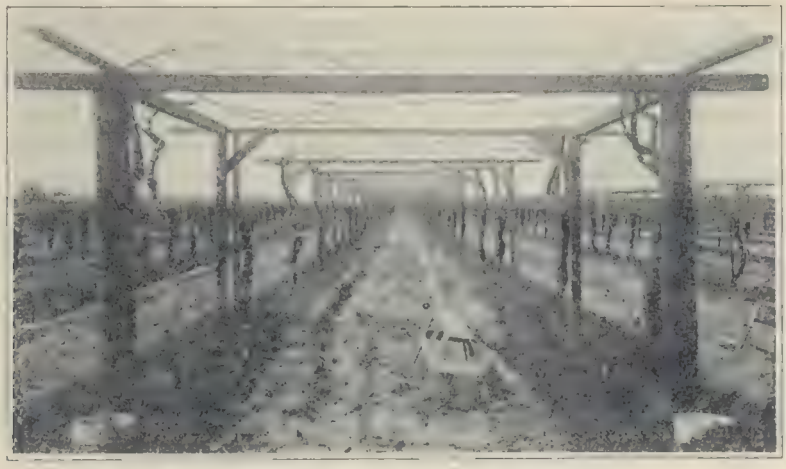


Fig. 7.—Ohanez vines on an arbor, cane-pruned.

The renewal spurs should usually be about one and one-half times as numerous as the fruit canes and should be so placed as to maintain or improve the form of the vine.

Cordon Pruning of Bearing Vines.—Since the annual pruning of the cordon vine consists in cutting to spurs, it resembles head pruning: in choosing the wood and estimating the number of buds to be left, the pruner proceeds in exactly the same way. To maintain the capacity of the individual arms at the same level, the length of the spurs left must be regulated in accordance with the size of the canes from which they are made. Long spurs should be bent sharply at the internodes or tied down to a horizontal position to cause the lower buds to grow; otherwise the arm may soon become too long. Sometimes short renewal spurs at the base of the long fruit spurs may be used advantageously.

Pruning Vines on Arbors.—The pruning of vines on an arbor or a pergola does not differ essentially from the pruning of other vines. The form given to the vine depends on the space to be covered and the fruiting habits of the variety. Thompson Seedless and other varieties that have mostly sterile buds on the basal portion of the canes must be cane-pruned. Such vines should be headed at or near the top of the arbor. The pruning is the same as described for the cane system (fig. 7).

Vines of other varieties should be trained and pruned as multiple, horizontal cordons; that is, each branch on the top, or side, of the arbor should be treated as a cordon. After the vine has been made to cover the required space, through the gradual increase and elongation of branches by the use of canes, spur pruning is preferable. Where a high wall is to be covered, the cordons at different levels should be provided by alternating high and low vines.

Summer Pruning.—Suckering, crown suckering, pinching, topping, and the removal of leaves are the operations in summer pruning. Suckering—the removal of water-sprouts from the trunk and from below ground—should be done carefully and thoroughly in every young vineyard and at least once each year in every old one. As a rule, no water-sprouts should be permitted on the undivided portion of the trunk of mature vines either above or below ground.

Crown suckering—the removal of water-sprouts from the branches and arms—should be employed with care. Sometimes one may open the head of the vine in order to improve the quality of the fruit or to concentrate growth in parts where it is wanted. To remove unfruitful shoots in all cases, on the theory that they are useless, is a mistake. The foliage they produce nourishes the vine and makes it more capable of bearing fruit. Also, some shoots may be needed for use as replacement spurs. The constant and thorough removal of all water-sprouts from the large branches and arms admits the direct rays of the sun and causes "bald-headed" vines, which are subject to severe injury by sunburn.

Pinching—the removal of the growing tip of a shoot with thumb and finger—is often useful in arresting the elongation of very vigorous shoots. This operation lessens wind damage and aids in developing young vines.

In topping, 1 to 2 feet is removed from the end of a growing shoot, usually in June or July. In very windy districts the practice may sometimes be advisable, for it may be better to cut off a part and save the remainder than allow the wind to break off the entire shoot. Since leaves are removed, however, the practice weakens the vine; and severe late topping may depress the next crop by as much as 70 per cent.

Judicious removal of leaves sometimes helps certain varieties to color; the operation opens the vines, permitting better exposure of the clusters. If the leaves are left on until the fruit has attained the minimum sugar content desired, neither the vine nor the fruit will be harmed. If many leaves are taken away before the fruit reaches the minimum sugar content for harvest, ripening may be retarded. To improve the coloring of the fruit, one should remove only the leaves in the head of staked vines and those on the lower part of the north or east side of trellised vines.

To aid in the production of fine table grapes one may remove, soon after the berries are set, any leaves that will rub the clusters and any tendrils that may intertwine the clusters.

DEVELOPING THE YOUNG VINES

The development of young vines in commercial vineyards follows a rather definite procedure—the use of pruning and disbudding to direct the growth, and the use of stakes or trellises to maintain the vine in the desired position. Usually four years are required to complete the training.

CARE DURING THE FIRST SUMMER

Throughout the first year, the main object is to develop a good root system. Cultivation and irrigation should be conducted with this in mind. The frequency of irrigation and the quantity of water applied will depend upon climatic and soil conditions. At least one irrigation, where possible, in late spring or early summer is always helpful in promoting growth of the comparatively shallow roots of the young vines. In hot climates two, three, or more applications may be needed. Late irrigation in the autumn should be avoided, because it may render the vines liable to injury from early winter frosts. Usually no pruning or training should be done in the first growing season, except in very hot regions, where the vines often may be trained during the first summer in the same way as described for the second summer.

By the end of the first growing season, the vines should have a well-established root system and a well-matured top growth. All of this top growth, except the strongest cane, should be pruned off sometime during the winter. The reserved cane is then usually shortened to two or three well-formed buds. The vines should be staked or trellised at this time if not earlier (before planting).

TRAINING DURING THE SECOND YEAR

The object of the second year's work is to develop a single strong, well-matured cane (with or without lateral branches) from which to form the permanent trunk. This is accomplished by disbudding in such a way as to direct the whole growing capacity of the vine into a single cane. Soon after the buds start and before any have developed into shoots of more than 4 inches, all but one should be rubbed off. The shoot reserved should be the one strongest and best placed for growing vertically near the stake. As this shoot grows, it should be tied loosely to the stake in order to keep it straight and vertical. It is first tied when 8 to 12 inches long and is re-tied once or twice more until it reaches the height at which the trunk divides; all other shoots should be removed from the old wood as they begin to develop. Laterals that grow on the reserved shoot should not usually be removed. If any of these below the middle of the shoot show signs of developing as rapidly as the main shoot, they should be pinched back. The main shoot should be pinched when it has grown 8 to 12 inches above the point at which the trunk will divide to form the branches or arms of the vine (fig. 8).

Up to this time the vines under all pruning systems are handled exactly alike. Beyond this point the training of the cordon differs from that of the head and cane systems, which remain alike for another year.

With vines to be head- or cane-pruned, all laterals on the upper half of the shoot are usually allowed to grow without pinching.

To form the bilateral horizontal cordon, two laterals (or the main shoot and one lateral) are selected to form the two branches of the vine. All other laterals are pinched back or, if vigorous, are removed entirely. The point where they divide should be 6 to 10 inches below the wire of the trellis that will support the cordon. When the laterals have made 18 to 24 inches' growth, one of them is tied in each direction on the trellis. As they continue to grow, they are kept straight by being tied loosely to the wire. No ties are placed on the portion of

the shoot that is elongating—a few inches to a foot or more from the tip, according to the rate of growth. The laterals are pinched after they have grown about 18 inches beyond the halfway point to the next vine.

At the end of the second summer, vines that are to be head- or cane-pruned should have developed a strong cane, which will form the permanent trunk, and several laterals on the upper half of the trunk cane. The trunk cane is cut off at the first node above the level where the head is desired. The cut should

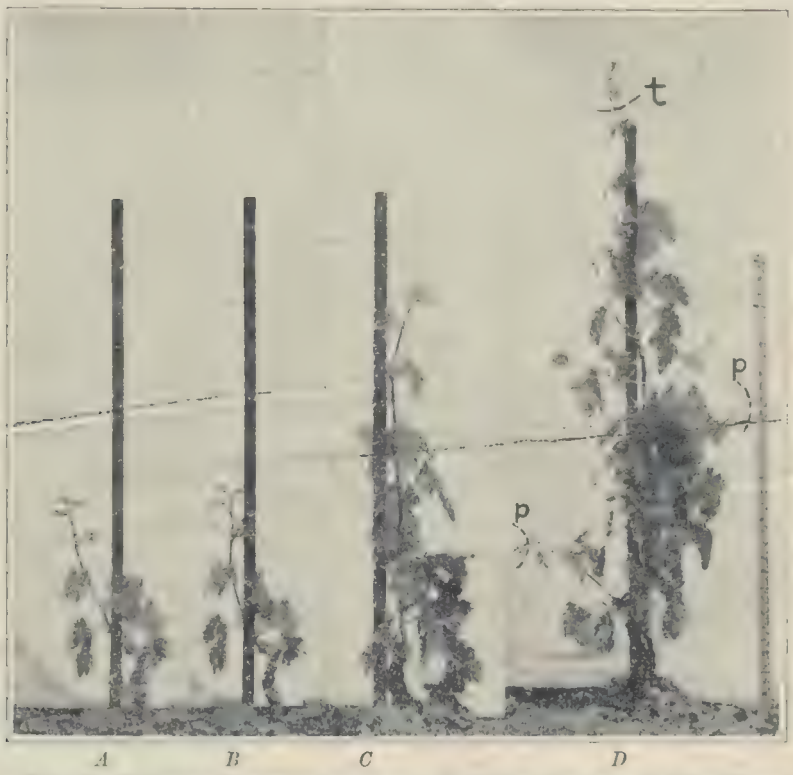


Fig. 8.—Training the second summer: *A*, Before the second disbudding; *B*, *C*, and *D*, manner of tying the reserved shoot to the support during the second summer. Strong-growing, low laterals are pinched at *p* to check their growth. When the main shoot has grown 8 to 12 inches above the height at which the trunk will divide, it is pinched, as indicated at *t*. (From Ext. Cir. 89.)

be made through the node in a way that destroys the bud but leaves the enlargement; this technique facilitates tying. All small laterals and all laterals below the middle are removed. On exceptionally large vines, one to three laterals over $\frac{5}{16}$ inch thick on the upper half of the cane may be cut back to one or two buds, according to their strength. These will act as fruiting spurs and will help to develop the head rapidly. A single fruit cane may be left on very vigorous cane-pruned vines.

Vines on which the trunk cane is less than $\frac{5}{16}$ inch thick at the desired height of the head should usually be cut back to two buds as at the first winter pruning.

A single hitch, two half hitches, or a clove hitch is made around the trunk cane just below the enlargement of the node that was cut through, and the string is taken twice around the stake and tied over the trunk cane as tightly as possible with a firm square knot. A loose tie is then placed around the stake and the trunk cane at about the middle; it must not pass around the cane between the cane and the stake, or the vine may be girdled. (For this manner of tying, see fig. 10.)

Cordon vines at the end of the second summer should have the trunk and the laterals for the branches fairly well formed. At the second winter pruning the branches should be cut back to a place where they are at least ½ inch thick. If they have grown sufficiently, they may be cut at a point halfway to the

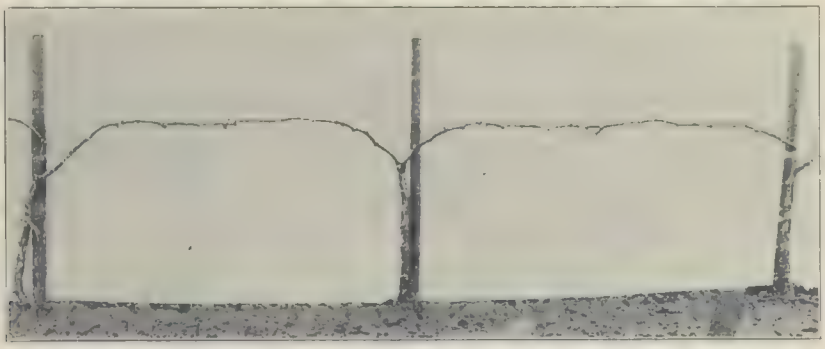


Fig. 9.—The completed trunk and branches of a horiontal, bilateral, cordon vine tied to the wire—the second (or third) winter. (From Cir. 277.)

adjoining vines (fig. 9). If the canes are not large enough to reach at least 12 inches along the wire beyond the bend, they should be cut back to within one or two buds of the point where the trunk was divided, and more vigorous canes grown the next year. All laterals on the trunk below the point of branching are removed entirely; and unless the vines are extremely vigorous, no spurs are left on the branches.

CARE DURING THE THIRD YEAR

The vines in the third summer will bear crops of varying amounts according to their size; the main object is, however, to develop the permanent branches. All shoots that start on the lower half of the trunks of head- and cane-pruned vines should be removed before they make much growth (fig. 10). Shoots starting on the upper half of the vine may be allowed to grow without interference except that the most vigorous may be tied or pinched if there is danger that the wind may break them off.

At the third winter pruning of a head-pruned vine, enough canes should be reserved and cut back to spurs to bear whatever crop the vine can carry without injury to its vigor or to the proper maturing of the grapes. The number will usually be three to six, according to the total growth. Each spur should be cut back to two, three, or four buds, according to the size of the cane from which it is retained. These spurs should be as near the top of the vine as is practicable.

Fig. 10.—Training the third summer: The first disbudding in head or cane pruning. (From Cir. 277.)

On cane-pruned vines one or two fruit canes, each 2 to 4 feet long, according to their size, should be left and tied to the supporting trellis. To supply canes for the following year, one should leave two to four renewal spurs, all as nearly as possible at the desired height of the permanent arms into which they will develop.

Cordon vines require much more care. When the vines start growing in the spring, the vineyard should be gone over several times, and the shoots growing on the underside of the branches rubbed off. This operation will remove about half the shoots and leave the other half, spaced 6 to 10 inches apart, on the upper side. At the same time, all shoots starting on the trunk or on the bends of the branches should be removed.

As the shoots that are retained grow at uneven rates, some will soon be much longer than others. These long shoots are usually either near the bends or at the ends of the branches. They should be pinched as soon as five or six leaves have formed. This pinching will check their growth and allow the weaker shoots to catch up with them.

On vines that do not extend the full length, a shoot is allowed to grow from near the end of the incomplete branch to complete it. This shoot should be tied to the wire to make the extension of the branch as straight as possible; a shoot from the underside of the branch is usually best.

As soon as the shoots are long enough, several from near the end of each branch must be tied to an upper wire. Otherwise the weight of all the shoots, together with that of the fruit, will turn the branch completely over, leaving the upper side bare and the shoots all pointing downward. If this trouble occurs and is not soon corrected, the vine can never be made into a good cordon.

Overbearing must be prevented. Usually, if the disbudding has been done as described, enough potential fruit will have been removed. If, however, the young vines bear more fruit than they can probably develop to good quality, some of it should be removed by thinning.

At the third winter pruning, spurs one to three buds long are retained at regular intervals, 8 to 12 inches, spaced along the upper side of the horizontal portions of the branches. All other canes are removed. All old ties on the trunk and branches must be cut, and the vine retied to make the horizontal portions of the branches as straight as possible. If deep sags are left, vigorous growth cannot be maintained on the sagging parts.

TRAINING DURING THE FOURTH AND LATER YEARS

In the fourth and subsequent years the aim is to perfect the structure of the vine so that essential operations will be facilitated and the vines will bear maximum crops of best-quality fruit. Head-pruned vines will be developed gradually into symmetrical forms. The heads of cane-pruned vines will be developed fan-shaped in the plane of the trellis, and thus will interfere as little as possible with cultivation. The arms of bilateral cordon-pruned vines should be uniformly spaced over the horizontal portions of the branches; one should maintain them upright by tying green shoots to the top wire, especially until the branches are large enough to resist the twisting effects of the growth and crop that might be heavy on one side of the trellis; they should be kept at the same height and at uniform vigor by careful pruning and judicious pinching.

During the summer all water-sprouts should be removed from the trunk below the lowermost arm on head- and cane-pruned vines. All water-sprouts, except those needed in developing new arms, are removed from the branches and trunks of cordon-pruned vines.

Vines that grow slowly may lag behind this program, whereas very vigorous vines in hot regions may be ahead of schedule. In either case the adjustment is usually made at the first or second winter pruning. Weak young vines may be cut back to two or three buds the second winter, a practice that delays the subsequent operations by one year. With very vigorous vines, the four years' work of developing may be completed in three years.

THINNING

Three distinct types of fruit thinning are used on grapes—*flower-cluster thinning; cluster thinning,* and *berry thinning.* All types of thinning owe their effectiveness to a reduction in the number of flowers or fruits and to the better nourishment of those that are left. Since each type of thinning, however, has a distinct purpose, the method chosen depends on the type of fruit produced by a variety or a vineyard.

FLOWER-CLUSTER THINNING

The clusters of rudimentary flowers of the grape appear with the leaves in early spring. The individual flower parts continue to develop until blooming occurs (from 6 to 8 weeks). The removal of some flower clusters soon after

Fig. 11.—A single cane of a Muscat vine, showing the proper stage of development for flower-cluster thinning. (From Bul. 519.)

they emerge, with no removal of leaves, improves the nutrition of those remaining. As a result, a better set of normal berries may be secured. Flower-cluster thinning is therefore useful on varieties that have loose or straggly clusters, or which set many shot berries with the usual pruning, such as the Muscat of Alexandria and Dattier. For best results the vines should be long-pruned (long spurs or fruit canes) and thinned as soon as possible after the flower clusters appear (fig. 11). This type of thinning should never be used on varieties that produce compact clusters, like the Tokay.

CLUSTER THINNING

Cluster thinning consists in the removal of entire clusters soon after the berries have set, after blooming. The most widely useful of the three types, it is the easiest and best means of reducing the crop on overloaded vines of wine- and raisin-grape varieties to insure that the remainder will develop and mature properly. By leaving enough fruiting wood (spurs or canes) at pruning time to produce a good crop in poor years and then reducing the overload in good years by cluster thinning, one may secure large, regular crops almost every year.

Cluster thinning, since it is not done until after blooming, does not influence the number of berries that set; and since entire clusters are removed it does not appreciably change the character of those retained. By improving the nutrition of the fruit that is left, cluster thinning enhances the size and coloring of the berries and hastens maturity. One may further improve the average quality of table grapes by retaining only the best clusters. At thinning time the clusters of table varieties should be disentangled from one another or from shoots around which they have formed. This operation will prevent damage to many fine clusters during harvest.

BERRY THINNING

As used in California, berry thinning consists in removing parts of the cluster, usually by cutting off the end of the main stem and several branches of the cluster, or by cutting off enough of the main stem to leave only the desired number of berries. This method can improve quality only when an overabundance of berries makes the clusters too compact or when overlarge cluster parts interfere with proper coloring and maturation. In the improvement of quality, therefore, its usefulness is limited to varieties that set very compact or very large clusters. Berry thinning usually changes the character of the clusters materially (fig. 14); it always reduces their size and sometimes alters their shape. The thinning should be done as soon as possible after the drop of berry forms (flower receptacles) that normally follows blooming—that is, as soon as the berries have set.

GIRDLING

Girdling, also called "ringing," consists in removing a *complete* ring of bark $\frac{1}{8}$ to $\frac{1}{4}$ inch wide from the trunk or from an arm or a cane below the fruit which it is intended to affect. As a result, the carbohydrates elaborated in the leaves will accumulate in the parts above the wound, including the clusters of blossoms or fruit, and will materially influence their development. The stage reached by the grapes at the time of girdling will largely determine the nature of the response.

GIRDLING TO IMPROVE THE SET OF BERRIES

Girdling done while the grapes are in bloom increases the number of seedless berries that set, but does not cause any additional seeded berries to form. It improves the yield of the Black Corinth, which, without girdling, produces small, straggly clusters consisting mostly of tiny seedless berries and a few medium-sized seeded ones. Girdling at this time increases the number and size of seedless berries without influencing the number that have seeds (fig. 12). The Black Corinth is universally girdled during the blooming period. Trunk girdling is favored over girdling the arms or fruit canes because it affects the whole vine uniformly. The trunks of the Black Corinth tend, furthermore, to remain relatively small, and trunk girdling is cheapest. Girdles $\frac{3}{16}$ inch wide are adequate. Wine-grape varieties, like the Pinot Chardonnay, which in occasional vineyards produce only straggly clusters, can be made to yield larger crops by girdling. The additional fruit consists entirely of seedless berries.

GIRDLING TO INCREASE BERRY SIZE

A complete girdle that is open and effective during the period of most rapid growth of the berries, which occurs within a few weeks after blooming, increases the size of seedless berries 30 to 100 per cent, but of seeded berries usually less than 20 per cent. Figure 13 reproduces, in natural size, photographs of Thompson Seedless berries from girdled and ungirdled vines. If the

Fig. 12.—Black Corinth clusters: *a*, From a vine that was girdled while in bloom; *b*, from an ungirdled vine. (From Ext. Cir. 56.)

operation immediately follows the normal drop of berry forms, after blooming, the greatest increase in size of berries is obtained with little or no influence on the number.

Thompson Seedless vines for producing table grapes are, therefore, girdled as soon as possible after the normal drop of the berry forms. If the girdling is done too early—before the normal drop is complete—the clusters become too compact. If it is delayed more than 10 days or 2 weeks after blooming, the increase in berry size is less. The girdling may be done on either the trunks or the fruit canes with almost equally good results. The girdles are usually made $\frac{3}{16}$ or $\frac{1}{4}$ inch wide and heal over in 3 to 6 weeks.

Thinning is nearly always necessary when Thompson Seedless are girdled. The increase in total crop, without thinning, is roughly proportional to the increase in berry size; hence vines that are girdled but not thinned are nearly always overloaded, with consequent poor quality of fruit and weakening of the vines. Thompson Seedless clusters from ungirdled vines are normally well

filled or compact. Since girdling increases the size of the berries but not the length of the stem parts, it increases the compactness of the clusters, often making them too compact (fig. 14).

The method of thinning will be determined in each instance by the character of the clusters. Cluster thinning (see p. 26) should be used to eliminate the least desirable clusters—those too compact, too small or too large, misshapen, or otherwise defective—leaving the required number of the best. Any of the remainder that are too compact must be berry-thinned (see p. 27). The forked-

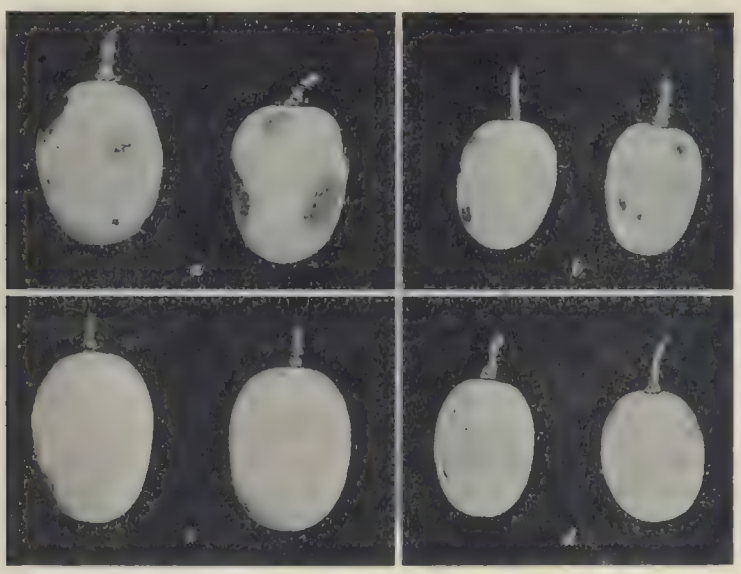


Fig. 13.—Thompson Seedless berries (all natural size): *a*, Girdled but not thinned; *b*, not girdled, not thinned; *c*, girdled and berry-thinned; *d*, berry-thinned but not girdled. (From Ext. Cir. 56.)

tip ends of all retained clusters should be cut off. In short, the thinning usually combines the cluster and berry methods.

Seeded varieties show less response to girdling. Although shot (seedless) berries of these varieties are improved in the same manner as are the berries of seedless varieties, the normal-seeded berries are increased only slightly in size. Nearly the same benefits may be obtained by thinning alone when a method suited to the variety is employed. Girdling to enlarge the berries of normal-seeded varieties is of doubtful economic value and is not recommended.

GIRDLING TO IMPROVE COLORING AND TO HASTEN RIPENING

To improve color and to hasten ripening, the girdles must be open and effective during the early part of the ripening period. Even then the desired result cannot always be obtained. The seedless varieties—Thompson Seedless in particular—are influenced in this respect but little, if at all. On the other hand, the coloring of Red Malaga and Ribier can often be improved. The rate of ripening of most seeded varieties—Malaga, Muscat, Red Malaga, Ribier,

and the like—may be accelerated. Girdling to hasten ripening and to improve coloring should be done just before ripening starts, when the first traces of color appear in the fruit. The best results are obtained from vigorous vines having only a light crop. With a normal to heavy crop, often no response will be obtained.

Girdling to hasten ripening is of doubtful economic value except sometimes in very early districts where a few days' advance in maturity may mean a great difference in price—sufficient to compensate for the reduced crops, the added expense, and the risk of failure.

Fig. 14.—Thompson Seedless clusters: *a*, From ungirdled vines, not thinned; *b*, unthinned clusters from girdled vines; *c*, berry-thinned clusters from girdled vines. (From Ext. Cir. 56.)

MAKING THE GIRDLE

Various types of double-bladed knives are used to girdle the trunks; a specimen is shown in figure 15. Work done with an ordinary single-bladed knife is usually less perfect and more expensive. Cane girdling is best performed with girdling pliers that have double blades on each side. With pliers such as those shown in figure 15 in position on a cane, one should cut through the bark by pressing on the handles, then release the pressure, rotate the pliers on the cane, and cut another section of the ring by squeezing the handles. This process continues until the cane is completely encircled. When the ring of bark has been cut completely around the cane, it is loosened by rotating the pliers, under slight pressure, around the cane. The bark removed will stick between the double blades but with further use of the tool, will pass on through between them. A spacing of $\frac{3}{16}$ inch between the double blades is recommended.

THE WEAKENING EFFECT OF GIRDLING

Because girdling stops the downward movement of organic food materials past the wound until after healing, the lower parts of the vine, particularly the roots, are undernourished while the wounds are open. The roots cannot explore new soil areas to get adequate amounts of water and other materials. The top growth is checked, and the leaves tend to become yellowish. The longer the wounds remain open, the more serious is the weakening effect. Trunk girdles that fail to bridge across during the growing season cause the death of the vines. Cane girdles that fail to heal are less serious. Girdles made during or soon after blooming, and not more than $\frac{1}{4}$ inch wide, will usually

heal in 3 to 6 weeks, whereas those made later or cut wider or reopened to influence ripening will heal more slowly and have a more weakening effect.

Good cultural care, particularly in irrigation and in thinning to regulate the crop, will make the girdle less weakening to the vine. The frequency of irrigation should be doubled while the wounds are open.

Overbearing of girdled vines must be avoided—with Black Corinth, by pruning; with Thompson Seedless and all other table varieties, by thinning to the extent that the girdled vines will not have more than two thirds of the maximum crop they could mature if not girdled.

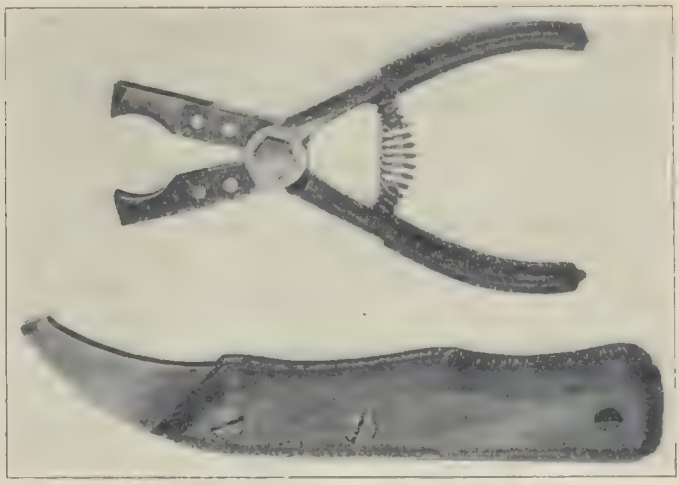


Fig. 15.—Girding tools: upper, cane-girdling pliers; lower, double-bladed trunk girdler.

If properly thinned and well cared for, Thompson Seedless vines may be girdled year after year. One experimental lot of twenty mature vines in Stanislaus County was girdled and thinned for eleven consecutive years with no apparent decrease in crop or growth.

In making the girdles, one should remove only the bark—the tissue outside the cambium layer. Cutting deeply into the wood is serious; it destroys many of the most active conducting vessels in the outer layers of wood and thus causes a lack of water above the girdle.

CULTIVATION AND WEED CONTROL

Cultivation is practiced in most commercial vineyards, but it varies widely in frequency and depth. It is beneficial in some respects: the purposes set forth in the next paragraph are often accomplished by this means more easily, more cheaply, and more efficiently than by any other. It may, however, be detrimental; it often breaks down a favorable soil structure and develops puddled surface soil, or compacted subsurface layers (plow sole). The present trend is to cultivate vineyards often enough and deep enough only to secure the desired results. Unnecessarily frequent and deep cultivation should be avoided.

PURPOSES OF CULTIVATION

The general purposes of vineyard cultivation are: (1) to destroy weeds; (2) to facilitate irrigation, pest control, harvesting, or the drying of raisins; (3) to prepare a seedbed for covercrops; (4) to incorporate covercrops and manures into the soil; and (5) to aid, temporarily, in the absorption of water where other vineyard operations have compacted or puddled the surface soil.

Weeds must be kept under control. In nonirrigated vineyards in California, control means complete elimination of weeds soon after the winter rains are over and before the weeds have robbed the soil of moisture needed to carry the vines through the rainless period. Where ample water is furnished throughout the summer, either by irrigation or by summer rains, control means that the weeds are not allowed to compete seriously with the vines for soil nutrients, nor to interfere with other vineyard operations. Clean cultivation is not everywhere practiced or advised.

Cultivation of itself does not conserve soil moisture. Evaporation from the surface dries out the top 4 to 8 inches of soil, whether cultivated or not. In a well-drained soil, moisture below the upper 8 inches is removed mainly by roots, not by evaporation from the soil surface. In tests comparing water removal by plants with water removal by surface evaporation, a tank of soil in which wild morning-glory was grown lost 120 pounds of water in 23 days, whereas a similar tank of bare, uncultivated soil lost only only 57 pounds in over four years.[7] Although this latter tank was not irrigated after an initial wetting, it still contained available water at the end of the four-year period. Cultivation in a vineyard does conserve moisture by destroying weeds, but only in that way. Destroying the weeds by other means is equally beneficial.

Furrows or ridges are needed to distribute irrigation water effectively. They interfere, more or less, with harvesting and especially with the drying of raisins between the rows. If the raisins are to be dried on paper trays, an almost essential step is to smooth the soil by cultivation and by dragging, before harvest. In vineyards of table and wine grapes the rough ground is less objectionable, although a light disking is sometimes desirable to reduce the roughness of the soil and to knock down the high weeds. Extensive stirring of the soil in table-grape vineyards in preparation for harvesting is avoided, in order to reduce dust deposits on the fruit.

Where covercrops are planted to improve the soil or to prevent destructive erosion, cultivation is usually necessary to prepare a satisfactory seedbed, without which one cannot obtain a good stand. Cultivation is also needed to incorporate the covercrop into the soil, if for no other purpose than to prevent fires. Fertilizers, other than nitrogen, tend to be "fixed" near the surface. To be useful to the vines, such fertilizers must usually be placed, by mechanical means, below the depth of ordinary cultivation.

Breaking up a compacted, or puddled, surface layer by cultivation may increase permeability of the soil to water, but this effect lasts for only a short time. Repeated cultivation tends to decrease permeability. If left undisturbed, the natural channels formed by such agents as earthworm burrows, cracking

[7] Veihmeyer, Frank J. Some factors affecting the irrigation requirements of deciduous orchards. Hilgardia 2(6):125–291. 1927. (Out of print.)

of the soil, and decay of roots will enable the soil to absorb water more rapidly than if these natural channels were broken up by tillage. Cultivation, particularly when the soil is wet, tends to form plow sole—a more or less impervious, compacted layer just below the depth of tillage. The probability of forming a plow sole may be lessened if one gives only the needed cultivations, when the soil is dry enough not to be compacted by the implement. When a plow sole has been formed, deep tillage is often used in an attempt to overcome it; but often the best remedy is to leave the soil untilled, or to give infrequent, shallow cultivations when the soil is not wet. Wetting and drying of the soil, and undisturbed plant roots may be more effective than deep tillage.

CULTIVATION IN UNIRRIGATED VINEYARDS

In the unirrigated vineyards of California the only water available to the vines throughout most of the growing season is that stored in the soil from the winter rains. Any weeds allowed to grow in the vineyard after most of these rains have fallen will use part of the water; hence the winter- and spring-growing weeds and covercrop should be destroyed soon after the winter rains are over. The growth of summer weeds must be prevented. Since cultivation is usually the most practical means of destroying or preventing weeds, unirrigated vineyards are cleaned up in early spring as soon as the soil is dry enough to work. The winter covercrop—to this time beneficial in reducing erosion and preventing a loss of nutrients by leaching—is incorporated into the soil by plowing or disking. Cultivation is repeated often enough to destroy or prevent further weed growth. In the absence of perennial noxious weeds, such as morning-glory and Johnson grass, cultivation usually may be discontinued as soon as the surface soil becomes too dry for seed germination; but, where perennial weeds are present, it must be continued as late and as often as is necessary to control them. The method of cultivation is relatively unimportant as long as it eliminates weeds, discourages erosion, and does not injure the vines. A wet, plastic soil, which may be puddled or packed by the implement, should not be worked. Rarely should cultivation go deeper than 6 inches.

CULTIVATION IN IRRIGATED VINEYARDS

The conservation of water is less important in irrigated vineyards than in unirrigated ones, because additional water may be supplied to replace that removed by both vines and weeds. Irrigated vineyards are usually cleaned up in the spring, and subsequent weeds are controlled during the period of rapid vine growth in order to reduce or eliminate the competition for soil nutrients. After early summer or midsummer, if enough irrigation water is available, weeds are controlled mainly to prevent interference with various operations. In raisin vineyards, where natural sun-drying between the rows is practiced, the soil between the rows is leveled and smoothed by cultivation and by dragging, in order to prepare a place for the trays. Often, in table-grape vineyards, cultivation is discontinued in early summer or midsummer, and a covercrop of grasses or other plants is allowed to grow; the same furrows or ridges are used repeatedly for irrigations. Many growers claim that use of the summer covercrop enables them to produce better table fruit than is possible with clean cultivation.

TILLAGE IMPLEMENTS AND THEIR USEFULNESS IN VINEYARDS

Plows, disks, chisel-tooth cultivators, harrows of various kinds (including the revolving and spring-tooth types), and plank or steel drags are useful in cultivating between the rows. The choice of tools is governed by the nature of the soil, the power available for pulling the implements, the distance between the rows, the nature of the winter covercrop, the manner of pruning-brush disposal, and the operator's preference. The same tools will not serve under

Fig. 16.—The Kirpy plow cleaning out the row between the vines.

all conditions. In close-planted vineyards, where the rows are spaced 8 feet or less, the moldboard plow is the main implement for the spring cleanup. Where a heavy winter covercrop grows in close-planted vineyards, the soil is generally turned toward the vines by shallow plowing, to cover the weeds in the row, as soon as soil conditions permit after the heavy winter rains are past (March or early April). Spring rains often produce another crop of grasses and weeds after the first plowing. When the spring rains are mostly over, but before the land becomes too dry to be worked easily, the soil is turned back to its original position by a second, slightly deeper plowing, and then is smoothed by harrowing. Later cultivations are usually done by disk, weed cutter, or spring-tooth harrow. The double plowing may, at first thought, seem unnecessary; but thus far no easier or cheaper method has been found. Disks small enough for such close-planted vineyards usually cannot chop up a heavy covercrop so economically as plowing can turn it under.

Vineyards with rows 10 feet or more apart are seldom plowed. The spring

cleanup and practically all of the summer cultivation are done by disking. Large, heavy disks will handle covercrops of almost any size and will also chop up the prunings that are incorporated into the soil along with the covercrop. To prevent such disks from cutting too deeply for summer cultivation, spools, which limit the depth of cutting, are often placed on the axles between the disks.

Some vineyards with rows 8 to 10 feet apart are disked; others are plowed. The tendency is toward disking where wide spacing, light soils, and light

Fig. 17.—Tractor-drawn disk with two Kirpy plows, one right and one left hand, attached to the back corners of the disk.

winter covercrop growth occur; and toward plowing where the opposite conditions exist. If plows are used, the pruning brush in the vineyard must be removed, or burned, or shredded.

With head-pruned vines and square planting (the rows and the vines in the rows spaced the same distance), cross-cultivation—cultivating in both directions—is frequently used to clean the spaces between the vines in the rows. With trellised vines or avenue planting (rows spaced farther apart than the vines in the rows), and often even with square planting, the vine rows are cleaned up with special tools. Of these tools, the Kirpy-type plow, sometimes also called French plow (fig. 16), is the most common. It may be drawn by a horse or a mule; or two plows, one right hand and one left hand, may be drawn by a light tractor, or hitched behind a disk (fig. 17), the operators riding on sleds. A very small amount of hand-hoeing is usually needed to remove the islands of broken but unturned soil immediately adjacent to the vines.

For the Kirpy-type plow to work best, the strip of unstirred soil underneath the rows must not exceed 18 inches (preferably 12). Bordering the strip on either side should be a furrow, or depression, into which the soil from beneath

the row can be turned. The ordinary disk, operated by a skillful tractor driver, will go close enough if the vines are headed high and the rows are straight. Many vineyards do not meet these requirements. The Molley plow (fig. 18), attached to the back corners of a 4-gang disk, is designed to reach under low-headed vines about 8 or 10 inches beyond the rigid frame of the disk. This device consists of 1 or 2 disks mounted on a low frame which is pivoted in its attachment to the disk, or plow. The frame is streamlined and the cutting disks are shielded over the front and top to prevent damage to the vines or

Fig. 18.—Two Molley plows attached to a tractor-drawn disk. These plows eliminate the need of single plowing ahead of the Kirpy plows. This is part of the equipment illustrated in figure 17.

stakes. Used alone, without the Kirpy, the Molley does fair work if the vineyard is cross-cultivated. Used in only one direction, it is inadequate. It does, however, enable the tractor operator to drive close to the vines (in preparation for the Kirpy work) without great danger of damaging them.

WEED CONTROL WITH OILS AND OTHER CHEMICALS

To avoid the ill effects of cultivation (impaired soil structure, poor penetration of water, destruction of roots in the top soil, and dust on the fruit), some growers have experimented with sprays of oils and other chemicals for weed control. Practical and economical results have been achieved without serious injury to the vines. At present the best spray material is a light oil, such as Diesel fuel, to which has been added a quantity of the aromatic compounds and other impurities removed from petroleum in the refining processes. Orchard-heater oil has been used with good results in citrus groves of southern California.[8] Where weeds are controlled entirely by oil spraying, a permanent

[8] Sullivan, Wallace, Paul W. Moore, J. C. Johnston, and Harold E. Wahlberg. Oil spray for weed control in noncultivated citrus orchards. 7 p. California Agr. Exp. Sta., Berkeley, Calif. July, 1944. (Litho.)

system of ridges or basins is constructed for irrigation. Other projects combine oil sprays with cultivation; the oil is used in the row or between the rows after midsummer, and most of the spring cleanup and early-summer weed control is done by cultivation. The quantity of herbicide oil required varies from as little as 15 to 20 gallons per acre per application for spraying the rows only, to 60 to 150 gallons per acre per application for complete area coverage. The number of applications (2 to 8 for the season) is determined by the kinds of weeds present.

Probably the main obstacle to unlimited expansion of weed control by oil spraying is the limited supply of oil. If other chemicals are discovered which are equally cheap and effective, yet available in larger quantities, weed control by spraying may become important.

SOIL EROSION AND COVERCROPS

SOIL EROSION

On rolling lands in semiarid regions, and even on gentle slopes in humid regions, soil deterioration is mainly the result of soil erosion. The erosion may be insidious, passing unnoticed for some years, but ruinously cumulative in the end, as it is with sheet erosion; or it may be spectacular, as it is when gullies are deeply cut, often by a single storm.

When rain falls faster on the unprotected surface of a soil than it can be absorbed, the pelting rain stirs up the surface soil in the water; and then the soil particles, suspended in the water, run off in surface drainage. This is sheet erosion. It does not occur if the rain falls so slowly that none runs off the surface, nor if the surface is covered by vegetation, or otherwise, to break the pelting force of the raindrops. Gullies are made by the rapid flowing of relatively large quantities of water. Gully erosion is reduced or eliminated if the flow is spread, through vegetation, or if the velocity is slowed, through vegetation, cross-slope collecting ditches, or check dams.

The judicious use of covercrops in vineyards on land subject to erosion cannot be too strongly advised. The covercrop is most valuable if it is well established and growing during periods of heavy rain; but it is still effective if heavy rains fall in the spring after a light disking has checked or killed the covercrop plants in preparation for the spring cleanup.

Covercrops serve in at least three ways to reduce or prevent erosion. First, as has been pointed out, the top growth covers and protects the surface, breaking the force of the rain and slowing the flow of the surface runoff. Second, the roots bind the soil, more or less, with fibers that tend to hold it in place. Third, covercropping, after a year or two, increases the rate of water penetration. The roots, on decaying, leave channels through the plow sole which reach deep into the subsoil. Further, the coarse vegetable matter in the soil makes the surface more porous. In a cover experiment[9] at Davis, a 6-inch irrigation disappeared from the surface of a covercropped basin in less than 24 hours, whereas across a levee, in an adjacent clean-cultivated check, the time required was a week.

The covercrop may consist of native, self-seeding plants, such as grasses,

[9] Proebsting, E. L. Fertilizers and covercrops for California deciduous orchards. California Agr. Exp. Sta. Cir. 354:1–15. 1943.

wild mustard, bur-clover, or filaree; or of sown grasses and legumes. Whatever the plants, they must be established early in the rainy period, so that the soil is covered with vegetation before surface runoff is likely to occur. Native plants, and also plants that are broadcast-seeded, grow over the whole area—between, around, and into the vines. Since the cleaning up of a vineyard that has heavy weed growth close to the vines is expensive, the cost of the spring cleanup has discouraged many vineyardists from the use of covercrops. Most of the extra cost is avoided, however, and most of the benefits in preventing soil erosion are still realized, if the covercrop is sown in strips between the rows. For this purpose a mixture of grain and vetch is excellent. About 25 pounds of oats or barley and 20 to 30 pounds of purple vetch per acre are drilled between the rows in one direction in strips 4 to 8 feet wide, according to the distance between the rows. The soil in the row is left unseeded, hence remains relatively clean. In California the seed is drilled into the dry soil at any time after midsummer; but it does not start to grow until the fall or early winter rains. Except on fertile areas not already eroded, a light application of fertilizer may be needed the first two or three years to stimulate a rapid early growth. One hundred pounds of ammonium sulfate per acre, or its equivalent in nitrogen (about 20 pounds) in some other form of fertilizer, is usually adequate; occasionally phosphorus, or potassium, may be needed also. The fertilizer is best drilled into the soil by means of an attachment on the seed drill. The strip of heavy vegetation thus obtained serves almost as well as a complete cover in preventing serious soil erosion; and it interferes practically not at all with normal vineyard operations. In unirrigated vineyards the covercrop must be destroyed by disking or plowing as soon as the heavy winter rains are past. If a downpour should unexpectedly occur after the covercrop is worked in, the presence of the straw and the roots will still largely prevent any damaging erosion.

WINTER COVERCROPS ON LEVEL LANDS

Much has been written concerning the importance of organic matter and the fertilizing value of leguminous covercrops. Soils rich in organic matter are usually fertile, largely because they contain more nitrogen. In relatively cool, humid regions the humus (decayed organic matter) content apparently can be increased by farming practices that incorporate much vegetable material, such as green-manuring crops, into the soil. In warm arid and semiarid regions, however, the destruction of organic material by biological processes is so rapid that accumulation in well-drained soils is almost impossible. Apparently, furthermore, much of the benefit attributed to increasing the organic content by the use of covercrops may really result from preventing or reducing soil erosion, and by improving the penetration of water. This reasoning is supported by experimental evidence (in orchards and vineyards) that usually no greater benefits are derived from a given quantity of fertilizing elements—nitrogen, phosphorus, and potassium—applied in the form of manure than from equivalent amounts applied in mineral fertilizers. In some soils, however, a liberal addition of organic matter may favorably affect soil structure in the surface layer and so improve water penetration. The roots of covercrop plants, on decaying, leave channels in the soil that also admit water. Cover-

crops growing during the dormant season of the vines use the available nitrates and thus may prevent leaching of the soluble nitrogen out of the soil. Although the importance of increasing the organic matter in arid soil has probably been overstressed, covercrops do have value, even on level lands not subject to erosion.

Leguminous covercrops may actually add nitrogen to the soil. The nitrogen is obtained from the air and fixed in chemical combination by certain bacteria growing in nodules on the roots of leguminous plants. The nitrogen thus fixed constitutes only a fraction of the nitrogen used by the plants; the remainder, often the greater part, comes from the soil. If the nodule-forming bacteria are present and if the crop is allowed to grow nearly to maturity, the nitrogen added by a legume covercrop may be considerable[10]—perhaps 40 or more pounds per acre under the most favorable conditions. When the covercrop is allowed to grow only during the winter and is turned under in March or early in April, at a very succulent stage, the accumulation of nitrogen is likely to be very low. In experiments at Davis,[11] neither winter nor summer covercrops have increased the total nitrogen in the soil.

In the coastal valleys of California, enough rain usually falls in November and early December to start grasses and other plants growing. Mild temperatures during the winter favor their growth, and by spring a heavy cover of native plants on fertile soils is obtained at no special cost. Wherever the rainfall meets the needs of both covercrop and vineyard, the grower should not discourage this natural winter cover, even on soils not subject to erosion. On poor soils he may promote it by making a light application of nitrogenous fertilizer in the fall. Where the rainfall is scant—less than 16 inches—and no irrigation water can be supplied, any covercrop may prove detrimental.

In the irrigated areas of California, rains sufficient to start a covercrop often do not come until late December. Seeding and fall irrigation are therefore needed to get a good growth by spring. Putting in the covercrop, including irrigation and seeding, usually costs $5.00 to $15.00 an acre. Often it would be wiser to spend this money for nitrogenous fertilizer. On such soils erosion is not a factor, because there is seldom a runoff from winter rains; or, if a runoff does occur, it carries away only negligible amounts of soil.

SUMMER COVERCROPS

In some irrigated table-grape vineyards, grasses and other plants are allowed to grow after early or midsummer. The fruit produced is clean—relatively free from dust—and it sometimes ripens earlier, colors better, and ships better than fruit from clean-cultivated vineyards. The differences seem to be greatest on shallow soils and least on deep, fertile soils. The practice is sometimes also observed in raisin- and wine-grape vineyards; but there the object is usually to reduce costs rather than to improve quality.

In nonirrigated vineyards which lack summer rainfall, any summer-growing plants, other than the vines, are detrimental; they use up water that is needed to carry the vines through the season.

[10] Mertz, W. M. Green manure crops in southern California. California Agr. Exp. Sta. Bul. 292:1–31. 1918. (Out of print.)

[11] Proebsting, E. L. Fertilizers and covercrops for California deciduous orchards. California Agr. Exp. Sta. Cir. 354:1–15. 1943.

IRRIGATION

THE SOIL AND SOIL MOISTURE

Besides rock fragments and clay, all natural soils contain organic matter, living organisms, air, water, and certain substances either dissolved or precipitated as salts. The water, containing the dissolved materials, and the air are held in the spaces, or pores, between the particles. The amount of water held by a soil fluctuates within a considerable range, and the amount of air varies approximately inversely with the water content. The pore space, or space not occupied by the particles themselves, constitutes 30 to 50 per cent of the volume of most soils suited to vineyard use.

When the pore space in the soil is completely filled with water, the soil is said to be *saturated;* no further moisture can be put into it. If drainage takes place, part of the water from a saturated soil will move downward and, to a lesser extent, laterally by gravity. The amount of water retained by the drained soil is called the *field capacity* of that soil. Although each soil particle holds a film of water over its entire surface, most of the water is held between the soil particles at their points and surfaces of contact. The field capacity of well-drained soils of uniform texture ranges from less than 5 per cent in coarse, sandy soils, to more than 35 per cent in clay soils, and even higher in soils containing much organic matter.

During the growing season, plants remove water from the zone of soil occupied by their roots (the root zone) until the moisture content of the soil reaches a point at which many plants wilt and do not recover unless more water is added to the soil. When this condition is reached, the soil in the major portion of the root zone is at the *permanent wilting percentage.* Growth and other functions of plants cannot proceed in a normal manner when the moisture content of the soil goes below the permanent wilting percentage; but some additional water can still be extracted by most plants, and even this small amount may be enough, in cool regions, for grapevines after harvest.

Readily available moisture may be regarded as that portion of the soil water between the field capacity and the permanent wilting percentage. Within this range, the plants get water from the soil so easily that no considerable differences in their growth apparently result from differences in soil-moisture content. The readily available water in soils varies from less than one fourth to more than three fourths of the field capacity; it bears no constant relation to soil texture. Some sandy-loam soils actually hold more readily available water than some clays.

MOVEMENT OF WATER IN THE SOIL

When rain falls, or when irrigation water is applied to the soil surface, water moves downward, wetting the soil to field capacity or temporarily above field capacity. A little rain or a little irrigation water simply wets a shallower depth of soil to its field capacity than a larger amount would do. It does not result in bringing about a moisture content less than field capacity; soils cannot be partially wetted, but must be wholly so or not at all. The boundary between the wet soil and the drier soil will be fairly sharp. A second rain, or

another irrigation, results in wetting to field capacity a second layer immediately beneath the one first wetted.

Lateral movement of water in a well-drained soil of uniform texture and structure is of small magnitude in comparison with the downward movement, and often does not exceed a few inches in distance. If furrows, in the furrow system of irrigation, are too far apart, some of the soil between them will remain dry because of the limited lateral movement. The occurrence of a plow sole, hardpan, or dense clay subsoil increases the lateral flow. Upward passage of water in a well-drained soil is almost negligible.

THE SOIL AS A RESERVOIR FOR WATER

The amount of readily available moisture in the soil in which most of the vine roots are growing represents the reservoir capacity of the soil for holding water useful to the vineyard. The grapevine, like deciduous fruit trees and other plants, shows no marked differences in growth and fruiting as a result of differences in moisture content of the soil, as long as the soil moisture content in all parts of the root zone is above the permanent wilting percentage.[12] Roots are not uniformly distributed, however, throughout the soil within the root zone; and the portions of soil that contain the most roots are likely to be depleted of readily available moisture sooner than other (usually deeper) portions that contain fewer roots. Vines continue to take water from the regions with fewer roots, but the amount obtained may be insufficient for normal growth. Under these conditions, with only a part of the root system functioning in soil that contains readily available water, the vines cannot get so much water as they would if the entire root system were in moist soil. The vines function normally, with no measureable variations, as long as the soil throughout the root zone contains readily available moisture; but they manifest a lack of water when considerable portions of the root zone reach the permanent wilting percentage, even though the moisture in other areas is still readily available.

The root zone in vineyards may be considered as starting just below the cultivated layer and extending to a depth at which root growth is limited by hardpan, dense clay subsoil, water table, lack of aeration, or some other difficulty. In very deep, coarse sandy or gravelly soils, grape roots go down 10 feet or more. Not many roots will be found below 8 feet in sandy loam soils, 5 or 6 feet in loams, and 2 or 3 feet in clays. The depth of rooting can be determined by soil borings made in late summer or fall, when the growth of the vines has been checked by lack of available water; the roots may be assumed to have gone at least as deep as the soil has dried out. One can then determine the approximate amount of readily available water by measuring the minimum quantity of water required just to wet the soil again. Although measurements made in this way are not precise enough for the irrigation engineer, the results are very useful to the farmer and approximate the reservoir capacity of the soil. This capacity varies from about 0.7 to about 3.0 inches of water per foot (in depth) of soil, and in the best sandy-loam or loam soils the total may amount to as much as 20 inches.

[12] Hendrickson, A. H., and F. J. Veihmeyer. Irrigation experiments with grapes. Amer. Soc. Hort. Sci. Proc. 28:151–57. 1931.

VINE RESPONSES TO SOIL-MOISTURE CONDITIONS

Under favorable conditions of soil moisture, nutrition, temperature, and cultural care, the seasonal growth cycle of bearing vines is characterized by a very rapid and succulent growth of the shoots in spring and early summer; a gradual slowing of shoot growth as the berries rapidly enlarge; and a marked reduction in rate of shoot growth during the ripening period, with growth almost ceasing by the time the grapes are ripe. During and after harvest, the vines should make but little new shoot growth; but they should retain their leaves, which may remain green or change to yellowish green, or red and green, or red, according to the variety.

An abrupt depletion of the water supply to a growing vine causes wilting of the leaves and succulent shoots. Such wilting occurs with vines growing in pots or cans when the soil reaches the permanent wilting percentage; sometimes it occurs under field conditions in vines growing on shallow soils in hot weather when the permanent wilting percentage is reached at about the same time in all parts of the root zone. Wilting seldom occurs on deep soils, because not all the soil reaches the permanent wilting percentage at the same time, nor within a very short time. As the readily available moisture disappears from successive portions of the soil, the vine adjusts itself, by lessened shoot growth, to the limitations imposed by the reduced, but not altogether exhausted, water supply.

A restricted supply—meaning, under vineyard conditions, that the readily available water is exhausted from some portions of the root zone—causes characteristic symptoms which the experienced vineyardist can easily recognize. Early in the season, while the vines are growing rapidly, a soft, yellowish-green appearance is imparted by the rapidly elongating shoot tips. This condition persists near to the beginning of ripening if none of the soil below cultivation depth is depleted of its readily available water. But if increasingly large portions of the soil become dry, the rate of growth diminishes, and the appearance gradually changes from the soft, yellowish green of the growing tips to the harder, darker, or grayish green of the mature leaves. This change in appearance seems to be caused altogether by a shortening of the growing tips. When most of the soil becomes depleted of its readily available moisture, growth ceases. Still further reduction in water supply causes curling of the leaves; then, with continued further reduction, the older leaves become desiccated and die, eventually dropping off. Under these conditions of gradual decrease in the water supply, vines do not wilt in the commonly accepted sense of drooping of the leaves. An observant grower can detect a water shortage by the changed appearance of the vines before serious injury results.

Insufficient water while the berries are rapidly enlarging prevents them from reaching full size; and the application of water after the period of rapid berry growth is past will not enable the undersized ones to become normal. A severe shortage of readily available water during the ripening period causes delayed maturity and dull color of the fruit; often it also causes sunburn. A slight shortage just before and during this period may actually hasten ripening, probably because it limits the shoot growth.

After the fruit is ripe, and especially after the harvest, vines seem able to

adjust themselves to a very limited water supply. Under moderate climatic conditions they will retain their leaves and their canes will ripen, but no further shoot growth will take place; this happens even though the soil throughout the major portion of the root zone is at the permanent wilting percentage. In the hot desert regions, however, only early-ripening varieties—mostly Thompson Seedless—are grown for table grapes. These ripen and are harvested during June and July. Neglect of such vines for the remainder of the season often causes serious damage; the vines must be irrigated at least once and often twice after harvest.

QUANTITY OF WATER NEEDED BY VINEYARDS

From 16 to 42 inches of available water, according to climate, soil, variety, and cultural conditions, are required for maximum crops of grapes. In the cool parts of the coastal valleys, on soils that will hold 12 inches or more of readily available water within the root zone, no considerable benefits appear to be derived from supplemental irrigation if the total rainfall exceeds 16 inches. Regardless of total rainfall, however, only the water held by the soil, and available to plants, is useful; hence, on shallow soils, supplemental irrigation may improve the growth and crops of the vines even in cool districts with much more than 16 inches of precipitation. On the other hand, grapes are being grown without irrigation in the Livermore Valley, where the rainfall is about 14.6 inches annually, and near Soledad in the Salinas Valley, where it averages less than 10 inches. Vines can adjust themselves to limited water supplies by early cessation of growth, small crops of fruit, and dropping of leaves in late summer; but they will not yield such large crops under these conditions as they would if additional water were supplied.

Many of the vineyards planted on the rolling lands bordering the coastal valleys of California would yield larger crops if additional water could be supplied. Vineyards on the deep, fertile, coastal valley soils, for which cheap water might be available, do not generally respond to supplemental irrigation, for such soils hold enough readily available water to supply the vines throughout the season. Some such vineyards can be and are irrigated in seasons of abnormally low rainfall, or in seasons lacking the usual spring rains.

In the warmer vineyard areas of the state, summer irrigation is practiced in almost every place where water is available. Table 2 gives the approximate total seasonal needs (rainfall plus supplemental irrigation) of available water for maximum crops of best-quality grapes. Where the rainfall is greater than the total amount indicated, in the table, as needed for maximum crops, the vineyards may or may not respond to supplemental irrigation; the response depends on whether or not the soil holds sufficient water in the root zone to supply the needs of the vines throughout the season. If the vines grow vigorously until near the beginning of the ripening period and nearly all their leaves remain healthy until late in the fall, little benefit is likely to be derived from supplemental irrigation. If, on the other hand, the vines cease growth by midsummer and drop many leaves before mid-September, additional water given in early summer probably would have increased both growth and crop.

To estimate the amount of irrigation water needed in regions of low rainfall subtract, from the appropriate figure in table 2, either the rainfall for the

season minus that lost by drainage, or the available-water-holding (reservoir) capacity of the soil, whichever amount is smaller. The minimum figure may be used for deep loam soils that do not need more than two applications per season; the higher figure, for shallow or light sandy soils that require more. Soils having a high salt content may need more water than the table indicates to leach the excess salt out of the root zone.

TABLE 2

APPROXIMATE AMOUNT OF AVAILABLE WATER REQUIRED FOR MAXIMUM PRODUCTION OF GRAPES IN VARIOUS REGIONS OF CALIFORNIA AND ARIZONA

Region	Approximate available water required*		
	Wine grapes†	Raisin grapes†	Table grapes†
	acre-inches per acre	*acre-inches per acre*	*acre-inches per acre*
Cool areas: the cooler parts of the north coastal valleys and rolling lands (region 1); heat summation less than 2,500 degree-days‡	16-20	.....§	.....§
Moderately cool areas: the middle parts of the north coastal valleys (region 2); heat summation 2,501 to 3,000 degree-days	16-24	.....§	.....§
Moderately warm areas: the warm parts of the coastal valleys (region 3); heat summation 3,001 to 3,500 degree-days	20-30	.....§	.....§
Warm areas: southern California valleys except the deserts; middle and lower Sacramento Valley; lower San Joaquin Valley; and the intermediate central valley area between the Sacramento and San Joaquin (region 4); heat summation 3,501 to 4,000 degree-days	24-30	24-30	30-36
Hot areas: middle and upper San Joaquin Valley, upper Sacramento Valley (region 5); heat summation over 4,000 degree-days	30-36	30-42	36-42
Desert areas: Coachella, Imperial, Palo Verde valleys of California: Salt River and Yuma valleys of Arizona	.....§	.....§	42-54

* Acre-inches per acre, including the rainfall held in the soil of the root zone and supplemental irrigation. Water that runs off the surface or that percolates below root depth is not included.
† Grapes classified according to intended use, not strictly on the basis of variety.
‡ Heat summation as degree-days above 50° F for the period April 1 to October 31.
§ Such grapes are not grown in this region.

THE TIME AND FREQUENCY OF IRRIGATION

During the dormant season—winter or early spring—all portions of the root zone should be filled to the field capacity of the soil by rainfall or by irrigation. Generally, in regions of low rainfall, this means applying more water than calculations show is the minimum required to wet the soil; no soils are uniform (nonuniformity is the rule, not the exception), and sufficient water must be applied to the unit area being irrigated to wet the areas that require the most water or that are the slowest to take the water. For this reason, varying quantities of water will percolate below root depth and be lost as drainage in local areas that offer least resistance to the percolation. One can determine the depth of water penetration by using either a soil auger or a soil-sampling tube.

In the spring, after growth starts, no additional water is required until some of the soil within the root zone is dried out almost to the permanent-wilting percentage. The vines will not benefit more from application made before this time, but the grower may have to start irrigating earlier than this in order to cover the vineyard before the last vines irrigated become too dry. The change in the appearance of the vines, caused by a reduction in rate of

growth, indicates when considerable portions of the soil have reached the permanent-wilting percentage. On deep soils, no great damage is likely to occur within several weeks after the symptoms of water shortage first appear; but when this stage is reached by vines growing on very shallow soil, such as San Joaquin or Rocklin loam, the available water remaining in the soil may be only enough to carry the vines for a few days longer without serious injury. Where only a small head of water is available, a long time may be needed to cover the vineyard; and unless irrigating is started before it is really necessary, the vines irrigated last may already be seriously injured.

In the mild climates of the coastal valleys, if irrigation water is available in seasons of short rainfall, or in those lacking the usual spring rains, one irrigation that wets most of the soil sometime in early summer or midsummer would benefit vineyards on deep soils; and two such irrigations would usually be ample for soils 1½ to 3 feet deep. Grapes should not be grown on soils less than 1½ feet deep. Most vineyards in these coastal areas are not regularly irrigated.

The coolest parts of the vineyard areas in the great interior valley of California and in southern California (region 4) receive enough winter rainfall to wet shallow soils to the depth of rooting; but deep soils are fully wet only in seasons of abnormally heavy precipitation. The summers are practically rainless. Irrigation, therefore, is needed almost every season. In practice, irrigation varies. The deep sandy-loam and loam soils may be filled to field capacity sometime during the winter or early spring and need no applications during the summer. This method gives good results only on the best soils—soils which will hold 20 inches or more of available water in the root zone. Other soils require summer irrigation: some of moderate depth and texture need it only once in early summer; others, more sandy or shallow, need it not only then but also in midsummer; and still others (Rocklin and San Joaquin loams), being very shallow, are irrigated regularly at 2- or 3-week intervals from late spring until the grapes are ripe. With these last soils, furrows or basins are placed in the vineyard in late May to be used the rest of the season; no cultivating is done thereafter.

The central and northern parts of the Sacramento Valley are hot; but, since they receive enough rain in most seasons to wet the soil fully, they usually do not need irrigation in winter or early spring. Summer irrigation is essential for best results; the number of applications depends on soil conditions. A few vineyards are unirrigated.

The San Joaquin Valley receives less rain—about 11 inches at Modesto, 10 at Madera, 9 at Fresno, and 6 at Bakersfield. In general, rainfall increases slightly to the east of the axis of the valley and decreases to the west. Summer temperatures are high. Practically all the vineyards of the valley are irrigated. Winter or early spring irrigation is common practice in the driest areas. The number of late spring and summer irrigations varies from 1 to 10; the main influences are soil conditions and the kind of grapes grown, but water is needed somewhat oftener toward the upper (southern) end of the valley. A few vineyards of early table grapes on very sandy soils in the hottest areas are irrigated after the harvest, but the practice is not at all general.

The interval between irrigations is shorter for table grapes than for raisin

and wine grapes. Many of the former are on shallow soils (Madera, Exeter, and San Joaquin series), from which water is removed at about the same relative rate throughout the root zone. Because of the very limited reserve of readily available water after a part of such soil reaches the permanent-wilting percentage, and the serious consequences of total depletion before the fruit is ripe, it is good vineyard practice to irrigate before the vines really need moisture; otherwise some will almost certainly suffer before all can be watered. Until near the beginning of the fruit-ripening period, table grapes even on deep soils are usually irrigated before much of the soil reaches the permanent-wilting percentage; most growers figure that the risk of injury from becoming too dry is greater than the cost of the more frequent irrigations. During the ripening period, most vineyardists who have deep soil either do not irrigate at all, or wet only a part of the soil if an application is required.

Raisin- and wine-grape vineyards are, in general, irrigated when the vines indicate, by a slight characteristic change in appearance, that the readily available water has been depleted from a portion of the root zone. Irrigation ceases sometime before or soon after the fruit begins to ripen.

QUANTITY OF WATER REQUIRED FOR AN IRRIGATION

The quantity of water applied at each irrigation varies between wide limits according to the dryness, depth, and water-holding capacity of the soil. Until near the beginning of fruit ripening, most growers aim to apply enough water to re-wet completely the soil of the entire root zone. Each grower must determine for himself the quantity needed. A probe (iron rod with a handle) or a soil auger is the only equipment needed. In soils of uniform texture, a probe usually can be pushed into saturated soil to a depth of 5 or 6 feet, if the water has penetrated that far. After the soil drains, however, an auger is usually needed. The maximum amount of water on any given soil will, of course, be required when the soil is driest; the amount needed for re-wetting is reduced if the soil is less dry. At each application, one should make regular and extensive use of the probe or the auger to learn how deep the water has penetrated; and various sections of the vineyard should be tested because the rate of penetration will vary with the soil. No general rule for the amount of water required to wet a soil can be given. Some soils will hold less than 1 inch of water per foot (in depth) of soil; others more than 2 inches.

Vineyards may be irrigated by furrows, basins, or checks. The furrow system, which requires the least labor, is the most common. The basin system, although it distributes the water most uniformly, requires more labor and is usually impractical in a trellised vineyard. The check system (resembling that used for alfalfa) is applicable only to very sandy soils where large heads of water are available.

FERTILIZERS

Of the three common fertilizer elements—nitrogen, phosphorus, and potassium—vines usually respond only to nitrogen. Economically favorable responses to phosphorus and potash are very rare in California. Vines respond favorably to nitrogen when a lack of that element is limiting their growth and productivity—a condition that can be determined only by trial applications. Test plots of 100 vines, or more, to which nitrogen is applied, alongside

of check plots on which none is used, are the best means of determining whether or not the vines will respond. For test purposes, 40 to 80 pounds of nitrogen per acre (200 to 400 pounds of sulfate of ammonia, or its equivalent) is recommended. Manures and winery pomace, if available at low cost, are good fertilizers. Application of 10 to 20 tons of these materials per acre is recommended if tests show a need for nitrogen.

PROPAGATION

Grapevines are commercially propagated in California only by cuttings or grafts. In soils not infested with or immediately threatened by phylloxera, nor heavily infested with nematodes, rootings produced from cuttings of the desired fruiting variety are used. Phylloxera and nematodes must be overcome through the use of resistant rootstocks, propagated by cuttings, on which the desired fruiting variety is grafted either before or after rooting.

CUTTINGS

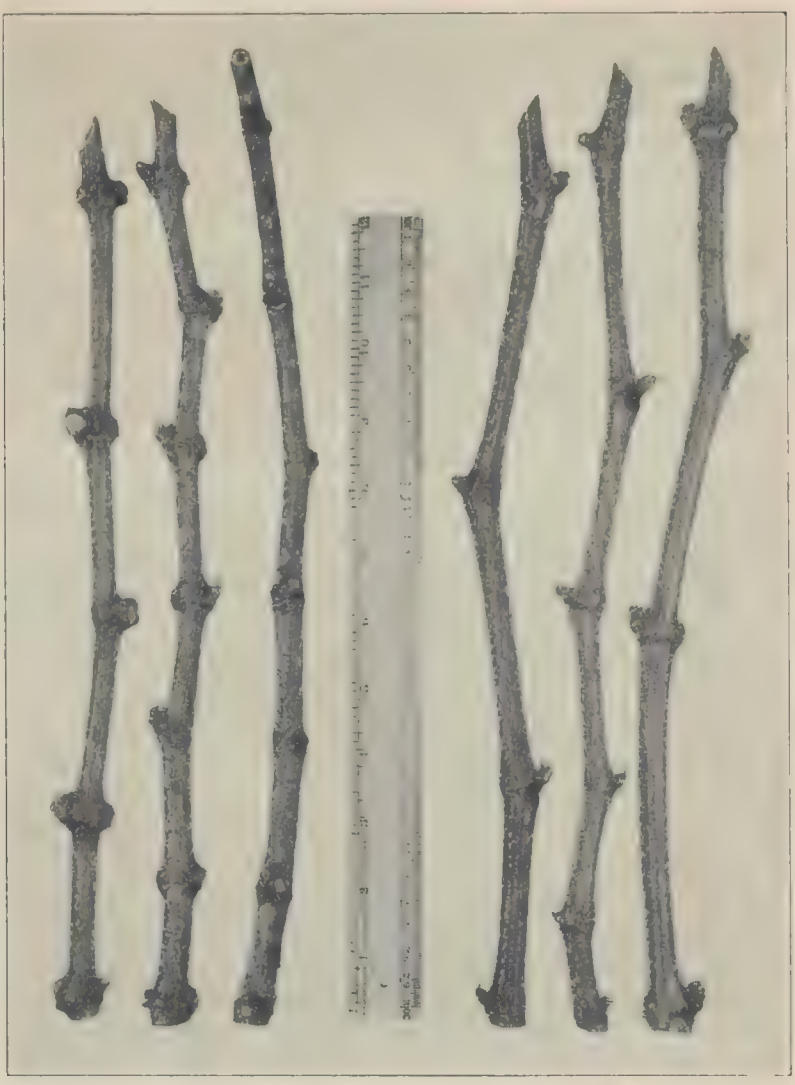
For grape cuttings, sections of canes (matured current season's growth) are always used. These should be taken from healthy, vigorous vines of the proper variety—preferably mature vines that have grown well, borne moderate crops, remained free from disease, and have not been injured by pinching, topping, or by autumn frosts. Usually one can gain little by selecting parent vines on the basis of past performance; still it is good practice to avoid off-types that are poorer than the average. These off-type vines may be of a different variety, or they may result from bud mutation. Most of such variations are inferior, though occasionally one better than the original may be found and propagated.

Grape cuttings should be made while the vines are dormant. They must be made promptly after the brush is pruned off the vines, since two or three warm, rainless, windy days may dry the brush to such an extent that cuttings from it will not grow.

For canes from which to make cuttings, well-nourished, well-matured, current season's wood growth from any part of the vine is suitable. Cuttings ⅓ to ½ inch in diameter and 14 to 18 inches long are commonly used. Seldom, if ever, should cuttings of the fruiting varieties be less than ¼ inch in diameter at the small end; a length of 14 inches is adequate. The resistant-rootstock varieties produce canes of smaller diameter than those of the fruiting kinds. Wood of normal size should be used. If the resistant cuttings are to be rooted, then planted in the vineyard, and finally budded, they should be longer than cuttings of the fruiting varieties—16 to 18 inches from the top bud to the base of the cutting.

The cut at the base of the cuttings is usually made straight across, just below a bud or node. The top cut is made at an angle of about 45° at a distance of ¾ to 1½ inches above the top bud (fig. 19). The angles of top and bottom cuts made in this manner will easily differentiate the top and bottom of the cutting in future handling operations. In addition the sloping cut, removed ¾ inch or more from the top bud, avoids any cracking of the wood in the node, which might allow the top to dry out and thus injure the bud.

Cuttings should be planted in a well-drained soil as soon as possible after they are made. The nursery row is usually the best storage place. If, however,



A *B*

Fig. 19.—Grape cuttings: *A*, Muscat; *B*, Emperor.
(From Ext. Cir. 101.)

they cannot be planted immediately, because of wet soil or other difficulties, they should be stored in a cool place, preferably in moist sand. For handling and storage, cuttings are conveniently tied into bundles of one or two hundred each.

The soil for the nursery should be fertile, preferably a sandy loam, with irrigation available. Even in the north coast region, where vineyards are grown without irrigation, it is impractical to grow a nursery without irrigation. The cuttings are planted usually to the depth of the second bud from

the top of the cutting, and are completely covered with a ridge of loose soil. Though the procedure will vary with the scale of operations and the equipment available, any method of planting is suitable that places the cuttings at the proper depth in a straight row, with the soil around them firmly settled. If they are put in a trench, one must pack the soil firmly around the base of the cuttings by tramping as the trench is filled or by irrigation. If the cuttings are stuck in the cut made by a subsoiler, one must settle the soil around them by irrigation while planting. In a fertile soil in a hot region, the cuttings may be placed as close as 2 inches apart in the row with the rows 4 feet apart. In a less fertile soil or in a cooler region, 3- or 4-inch spacing in the row will produce larger and better rootings.

During the summer the nursery should be carefully tended so that roots and tops will grow well and yet be matured before autumn frost occurs. This aim is usually best accomplished by irrigating rather often in the spring and early summer, less frequently in late summer, and not at all in the last 6 or 8 weeks of expected growth. The ridges of soil over the tops should be left until the cuttings have rooted and made appreciable top growth. Then one may remove the ridges to discourage the formation of surface roots.

The rootings may be dug any time after the leaves fall. They should be sorted according to size into at least two grades, and bound into bundles of 25 or 50 each for convenience in handling. Until used they should be stored by heeling-in in moist sand or soil in a cool location. Rootings that have made less than 6 inches of well-matured top growth or that do not have at least one good root ⅛ inch in diameter from the basal node of the cutting, should not be planted in the vineyard.

BUDDING AND GRAFTING

Only the methods of grafting applicable to vineyard use are given here.[13] Usually the actual budding or grafting is best done by a skilled workman. By following the directions given below, however, anyone can obtain good results.

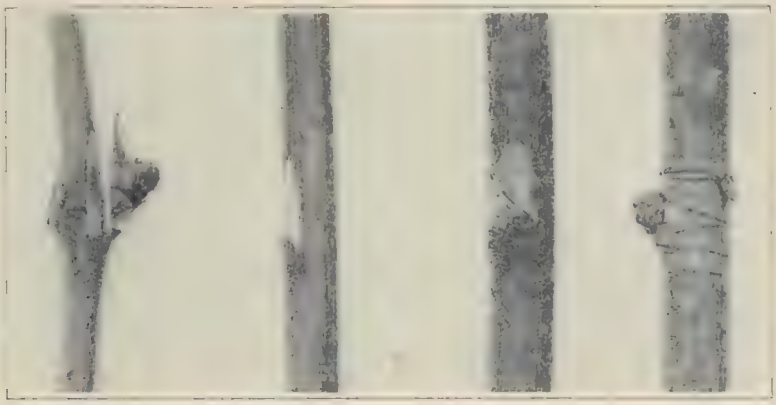
Budding.—Stock rootings of resistant varieties that are to be budded or grafted should be made "sucker proof" by removal of all eyes or buds from the below-ground portion before planting. They should be planted with 2 or 3 inches of their main body above the surface of the ground so that the graft can be put in aboveground; scion roots can thus be avoided. Budding is done as early in the autumn as matured buds of the desired fruiting variety can be obtained—usually in August or September. The bark of the cane from which buds are taken must be light brown, since many buds from green canes or green parts of canes will not grow. As soon as the canes (bud sticks) are taken from the parent vine, the leaves are removed; and the bud sticks are kept fresh by being wrapped in moist burlap or packed in wet moss or other suitable material.

A special form of chip bud (fig. 20) is most commonly employed. To remove a bud from the cane, two cuts are necessary. The first is made deep into the bud stick, beginning just below the bud and sloping downward at an angle

[13] The methods of bench grafting used only by commercial nurserymen are described in: Jacob, H. E. Propagation of grapevines. California Agr. Ext. Cir. 101:1–36. 1936. (Out of print.)

of about 45°. The second cut is started about ⅝ or ¾ inch above the bud; and the knife, traveling in a nearly straight plane behind the bud, ends at the surface of the first cut, removing a wedge-shaped chip ⅛ to 3/16 inch thick at the lower end and a little less than 1 inch long (fig. 20, *A*). Some workmen reverse the order in which the cuts are made. The wood in the chip is not removed from the bud.

A notch into which the bud will fit well is made in the stock just above ground level, preferably on the side of the vine from which most of the top growth arises. The work is easier if one first removes the soil around the vine to a depth of 3 or 4 inches. The angle made by the two cut surfaces of the notch



A *B* *C* *D*

Fig. 20.—Steps in budding vines: *A*, The bud removed from the bud stick; *B*, notch made in the stock to receive the bud; *C*, the bud in place; *D*, the whole finished and tied, ready to be covered with soil.

in the stock may be slightly more acute than the angle formed by the cut surfaces of the bud piece. This technique insures intimate contact between the lower end of the bud piece and the corresponding cut surface of the stock. The bud chip must be so inserted into the notch that a good fit is obtained. It is then securely tied in place with budding rubber (fig. 20, *D*).

Immediately after being tied, the bud is covered with moist, well-pulverized soil; and this, in turn, is covered with 4 to 8 inches of well-pulverized soil. If the soil is fairly moist, a covering 4 inches deep may be adequate. If the soil is dry, an 8-inch covering is better. In very dry soil it is well to cut off one fourth to one half of the tops of the vines at the time of budding. The bud is callused-in—that is, it grows fast to the stock—within 4 weeks. It usually remains dormant, however, until the following spring.

During the winter, field-budded vines need no attention, provided the staking or trellising has already been done. Because of the danger of damaging the buds in driving the stakes, it is best to stake the vineyard before planting. The following spring, when the buds on the rootstock vines are swollen and nearly ready to break, the scion buds should be uncovered. The usual procedure is then as follows: Cut the rubber used for tying. On each vine, carefully examine the scion bud to ascertain that it is alive and grown

fast to the stock; do not hesitate to apply considerable pressure to the bud chip, for if the union is good, the chip can hardly be dislodged by one's fingers. If the scion bud appears well united with the stock and is beginning to grow, cut off the stock 1 or 1½ inches above the bud. Place a building-paper sleeve about 1½ or 2 inches in diameter and about 9 inches long over the end of the stock and the scion bud, banking 3 or 4 inches of loose soil around the lower end of the sleeve to prevent the wind from blowing it away. Suitable sleeves may be made by rolling 9-inch squares of waterproof building paper in the form of tubes. This practice protects the buds and scion shoots from damage by wind, cutworms, rabbits, and drifting soil. The sleeves also force the scion shoots to grow upright, and thus facilitate training. As soon as the scion shoot grows up through the sleeve, tie it to the stake. Remove all stock suckers and scion roots whenever they appear. If the scion bud is not good, the vine may be regrafted immediately or may be pruned back to one or two buds and then rebudded the next fall. When the vines are large, grafting is preferred; but when they are small it is best to rebud the next fall.

Often stocks are killed by being cut off when the scion buds are imperfect. Unless one is experienced it is not easy to find all the poor unions. Rootstock rootings properly disbudded before planting grow only from the top or from the scion bud; hence, if the top is cut off and the scion bud fails to grow, the vine is lost. To avoid this danger one may proceed as follows:

About the time the rootstock buds are ready to break, uncover the vines to expose the scion buds. Prune all the canes on each rootstock back to base buds. Cover the scion bud lightly (an inch) with loose soil, or place over it a building-paper sleeve. Watch the vines closely, going over the vineyard about once a week. As the scion buds start, cut off the tops of the rootstocks an inch or more above them. As the scion shoots grow, tie them carefully to the stake as in training any other vines. Thereafter keep the soil away from the base of the scion shoots to discourage scion roots, take off all stock suckers that start from the rootstocks, and *remove the rubbers* after the lower parts of the scion shoots have hardened (May or early June).

Each time, in going over the vineyard, remove all shoots from the stocks on which the scion buds have not started. Sometime in May, uncover the remaining scion buds that have not started and are thought to be defective, cut the rubbers, and examine the buds. Thereafter, allow the shoots to grow on all stocks that have defective scion buds. Rebud these next fall.

To regraft budded vines whose buds have not grown, or to correct plantings of mixed varieties, or to change the variety in an entire vineyard, the grafts commonly employed are whip, cleft, or notch.

Whip Graft.—For vines less than ¾ inch in diameter the long whip graft (fig. 21) is perhaps best.

The sloping cuts are made at an angle of 15° to 25° with the side of the stock or scion and must be the same length on both stock and scion. The tongue cut is started about one third of the distance from the point and it ends at about two thirds of the distance from the point to the base of the cut. Opening out the tongues by bending them over with the knife as it is withdrawn aids in putting the scion on the stock. The parts are pushed together, tongues interlocking, until the cut surfaces coincide as completely as possible. If the

Fig. 21.—The long whip graft: *A*, The sloping cuts made on the stock and scion; *B*, the tongues cut and opened out; *C*, the completed graft, tied, and ready for covering. (From Ext. Cir. 101.)

stock and scion are of the same diameter, a good fit can be obtained all around. If one is larger than the other, one side must be fitted so that the line between the bark and the wood of the scion coincides with the corresponding line on the stock as completely as possible on that side. This line is the position of the cambium layer. The graft is then tied very firmly with budding rubber, raffia, or string. If rubber is used, it must be cut and removed after the graft has firmly grown together.

Cleft Graft.—Vines ¾ to 2 inches in diameter are cleft-grafted most easily. The vine is sawed off so that about 2 inches of smooth, straight grain is left at the top of the stump (fig. 22, *A*, at *S*). If one saws at, or too near, a place where the grain of the wood is crooked or curly, great difficulty will be experienced in obtaining a good fit.

Vines of fruiting varieties, grafted merely to change the variety, are usually sawed off 2 to 4 inches below the ground level. *When resistant stocks, how-*

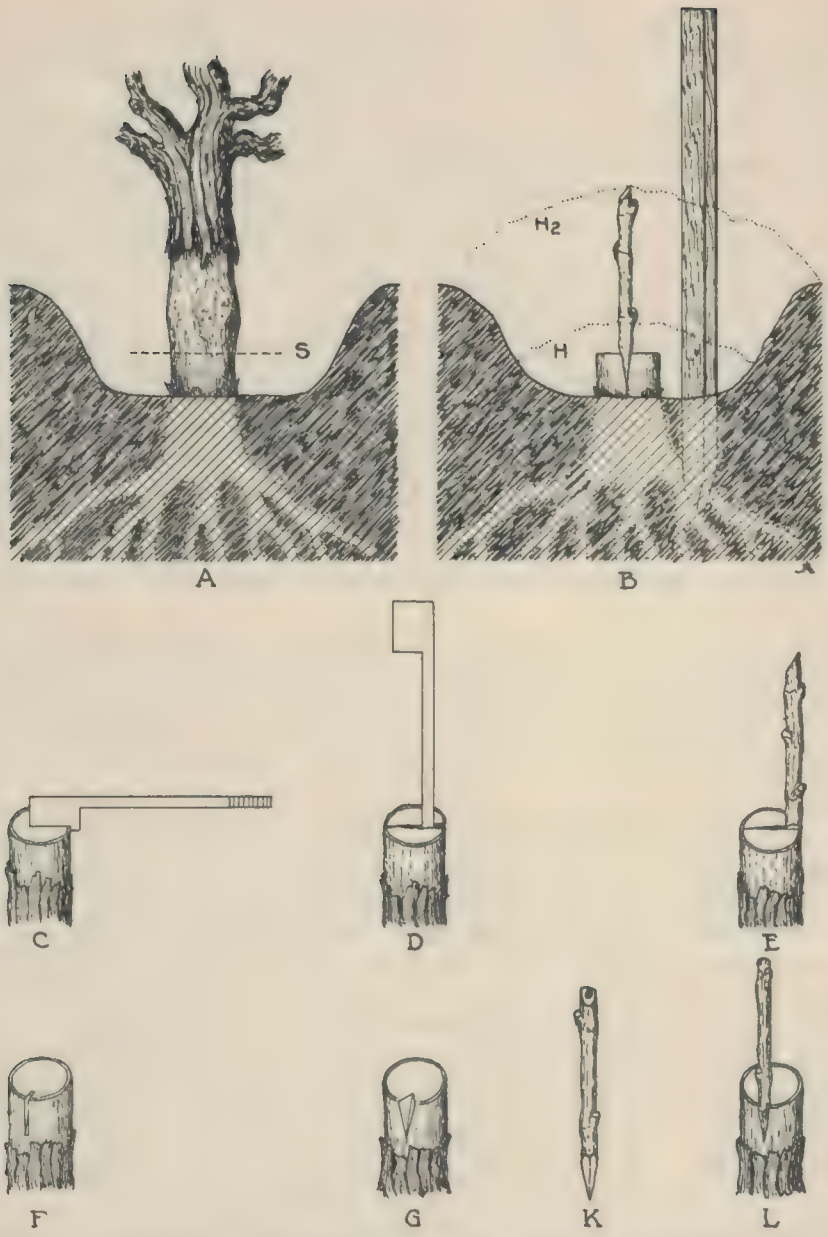


Fig. 22.—Operations in grafting: *A*, Where trunk is cut off; *C*, *D*, *E*, steps in cleft grafting; *F*, *G*, *K*, *L*, steps in notch grafting; *B*, the graft ready to be covered with soil. For details of operations, see the text. (From Cir. 115.)

ever, are grafted to a fruiting variety the graft must be put in above the level of the ground; if the grafting is done below ground, scion roots will form, and the resistant stocks may die. Resistant stocks are therefore cut off just above ground level.

The top of the stump at the place where the scion is to be inserted should be trimmed smooth with the grafting knife, so that the line of the cambium layer can be easily seen. The stump is split to a depth of 1 or 1½ inches with the broad edge of a special grafting tool (fig. 22, *C*); a carpenter's chisel may be used instead but is less convenient. After splitting the stump, the grafting tool is removed; and the small end is placed in the cleft to pry it apart for insertion of the scion (fig. 22, *D*).

The scion is cut in wedge form, a little thicker on the side that is to be placed nearest the bark of the stock. The length of the wedge depends on the character and size of the cleft in the stock. The wedge—usually with a long taper—is inserted so that the cambium of the scion coincides with the cambium of the stock. As the bark is thicker on the stock than on the scion, the outer surface of the scion will be set in slightly from that of the stock. Although the cambiums of the stock and scion will seldom correspond exactly, a satisfactory union is obtained if they are very near together or cross in one or two places. Most grafters put the scions in at a slight angle—in at the bottom and out at the top.

The scion should be cut with a sharp knife and immediately inserted in the stock before it dries even on the surface. Scions of two buds are generally used.

If the vines are an inch or less in diameter, one scion to each vine is sufficient. For larger vines, two scions are preferable whenever both can be made to fit securely. If both of them grow, the weaker is removed at the next pruning.

To hold the scions firmly in place, vines less than 1½ inches in diameter should usually be tied with a few tight wrappings of raffia, string, or budding rubber around the top of the stump. Larger vines need not be tied. Any rubber used for tying should be removed after the grafts are firmly grown together.

Notch Graft.—The notch graft differs from the cleft graft in the shape of the scion and the method of insertion. Instead of being wedge-shaped and inserted in a cleft or split, the scions are shaped to fit into a V-shaped notch on the side of the stock extending from the top of the stump downward for 1 to 1½ inches. The width and the depth at the top of the notch should be about the same as the diameter of the scion to be used. The notch tapers to a point at the bottom. The scion should be fitted into it so that the cambium layers of scion and stock coincide as completely as possible.

One can form the notch in the stock most conveniently by first making a saw cut as long and as deep as the notch is to be (fig. 22, *F*). Then, with a sharp knife, the notch is widened at the top and tapered to a point at the lower end (fig. 22, *G*). When finished, the cut surface should be smooth and straight, for if it is rough and irregular, a good fit with the scion cannot be secured. The angle formed at the bottom of the notch by the cut surfaces should be about 90°.

The scion should be so shaped that when it is placed in the notch, the cambiums of the stock and scion fit together. The angle that the cuts of the scion

make with one another may be slightly more obtuse than the angle of the notch. Thus, when the scion is placed on the stock, the contact will be firm at the line of the bark, insuring close contact of the cambium layers. Figure 22, *K*, shows a scion properly shaped to fit the notch in the stock (fig. 22, *G*).

After insertion in the notch the scion should be held firmly in place until the tissues grow together. This is accomplished most easily by driving in one or two 1-inch, 19-gauge, flat-headed wire nails (fig. 22, *L*).

Covering the Graft.—As soon as the graft is finished the stake should be driven close to the vine, unless a stake is already there. The graft is then carefully covered at once with a wide mound of moist, well-pulverized soil. No wax and no covering other than moist soil need be used. The soil immediately around the scion should be put in place with the hands so that the position of scions is not disturbed (fig. 22, *H*). The scions are completely covered. If the weather is cool and moist and likely to remain so until the scions grow, merely covering them to their tips is sufficient. In the hot, dry weather of the interior valleys, however, scions should be covered to a depth of 2 or 3 inches so that they cannot become even slightly dry. When finished, each graft will be in the middle of a wide mound of soil (fig. 22, H_2); narrow mounds may not remain moist enough to insure growth of the graft.

The mounds must not be disturbed by hoe or cultivator until the unions are well formed. If the scions are completely covered and the mounds form a hard crust, this crust should be carefully broken with the fingers.

Suckering Grafted Vines.—Many large, vigorous shoots may come up from the stock. When the grafts have started to grow vigorously, so that the shoots can be tied to the stake, it is safe to begin suckering. At this time the workman can sometimes pull up the suckers by hand without removing any soil. Unless he is certain, however, that they are not entangled with the scion, he must carefully remove some soil and ascertain how to detach them without disturbing the union.

If grafts are slow in starting and if the suckers are vigorous, one must sucker before the scion has grown much. One can do this safely only by using extreme care.

Training Grafted Vines.—When the union is complete, the growth of the grafts on large vines is generally rapid—often an inch a day; many canes grow 15 feet or more by the end of the season. Unless this vigorous growth is properly managed, its benefits are lost, and it causes great trouble the following year. The shoots are managed exactly the same as on exceptionally vigorous, ungrafted vines.

Cost of Grafting.—The cost of grafting over an old vineyard is always heavy—between 10 and 20 cents per vine. In addition, one must consider the cost of cultivation, of stakes, and of having no crop for one or two years. Grafting resistant rootstocks that have grown in the vineyard for only one or two years costs less than grafting old vines, but considerably more than fall budding.

HARVESTING TABLE GRAPES

Most of California's table grapes are marketed 2,000 miles or more from the vineyards. Transportation is principally in railway cars refrigerated with ice, and the time required is 7 to 11 days or more. The temperatures in the

refrigerated cars after the fruit is cooled usually average about 45° F. To market grapes successfully under these conditions requires care and skill in harvesting and packing to insure that the fruit leaves the shipping point in the best possible condition.

Grapes marketed within the state are not subjected to such a long journey. Varieties of somewhat poorer carrying qualities but of better eating quality, such as the Muscat, can therefore be placed on the local markets.

THE TIME TO PICK

In determining the best time or stage of development for picking table grapes, the chief considerations are: (1) They should be attractive to the consumer in appearance and in eating quality; (2) they should keep and carry well; and (3) they should, if possible, reach the market while prices are high.

Ripening, as it interests the grower, consists largely in an increase in sugar, a decrease in acidity, and the development of characteristic color, texture, and flavor. These changes are continuous as long as the grapes remain on the vine, but practically cease after picking. Under normal conditions there is a gradual improvement until the best stage is reached for the purpose to which the grapes will be put, then a gradual deterioration takes place.

Early in the season there is a tendency to market unripe fruit, which, though often sold for a high price, disappoints the consumer and ultimately depresses the market. The fact is recognized in the fruit and vegetable standardization laws of California, enacted to promote the industry by preventing, as far as possible, the shipment of inedible fruit, together with fraudulent practices in packing and selling.

THE MEASUREMENT OF MATURITY

Of the changes involved in the ripening of grapes, only the content of sugar and acid can be measured accurately and conveniently. In a few instances color definitions can be given.

For practical purposes, the sugar content of ripe grapes is measured accurately enough with a hydrometer (saccharimeter). These instruments are generally calibrated in the Balling or Brix scale and read directly in per cent sugar by weight. The hydrometer measures specific gravity (weight per unit volume as compared with that of pure water). In ripe grapes, sugar is the chief substance affecting specific gravity. In comparison with sugar, other dissolved substances have a small effect; hence one may estimate the quantity of sugar present by measuring the specific gravity.

Hydrometer Sugar Test.—For the sugar test a representative sample, 2 or 3 pounds or more, of the grapes to be tested is chosen. The grapes are thoroughly mashed in a pan or a pail with the hands or with a wooden masher or by being passed through a crusher. To press the juice from the pulp a square of cheesecloth is placed over a pan or a pail and the pulp poured upon it. A bag is formed of the cheesecloth by gathering together the edges; the bag is gently pressed with the hands until sufficient juice is extracted. The extracted juice is poured into the cylinder to be used with the hydrometer. The cylinder should be filled to overflowing. The foam that forms, as the juice is poured into the cylinder, is then blown off. The hydrometer, which should be clean and

dry, is then inserted into the juice until it comes to rest of its own accord. The hydrometer is read at the general level of the liquid and not at the top of the meniscus (curvature of the surface). The temperature of the juice is carefully taken, and the temperature of calibration shown on the hydrometer is observed. If the temperature of the juice is higher than the calibration temperature shown on the hydrometer, 0.33° Balling (or Brix) for each degree Fahrenheit difference in temperature (0.06 for each degree centigrade) is to be added; but if it is lower, the correction is subtracted. The result—the corrected or true reading—is the approximate percentage of sugar.

Acid Titration.—To determine acid is more difficult. A pipette is used, and 10 cubic centimeters of the clear juice are measured into a flask of convenient size. Fifty to 100 cc water[14] and one or two drops of phenolphthalein indicator solution are added. A standardized solution of sodium hydroxide (0.133 normal) is slowly run from a burette into the flask containing the diluted juice, with a constant stirring or shaking of the flask, until a faint pink color is obtained that lasts 10 seconds or more. A solution standardized to 0.133 normal is equivalent to 0.01 gram tartaric acid per cubic centimeter.[15] The result is expressed in grams tartaric acid per 100 cc of juice. If the procedure is carried out as prescribed, the number of cubic centimeters of the sodium hydroxide solution used, divided by 10, equals the tartaric acid in the juice in grams per 100 cc.

Balling-Acid Ratio.—The Balling hydrometer reading divided by the acidity, in grams per 100 cc,[16] gives the Balling-acid ratio—a better measurement of the palatability of table grapes than either the sugar content or the acidity alone. The minimum desirable Balling-acid ratio varies with different varieties. The Thompson Seedless, Malaga, and Ribier should be about 25 to 1—that is, 25 parts sugar to 1 part acid; the Ohanez, Cornichon, Muscat, and Emperor 30 to 1; the Tokay, Olivette blanche, and Red Malaga 35 to 1.[17] All of the varieties except Ribier and Red Malaga should, in addition, have a Balling of 17° or higher; the Ribier and Red Malaga should be at least 16° Balling.

Climatic conditions affect the relative amounts of sugar and acid, and their influence is reflected in the Balling-acid ratio: If the weather is very hot during the ripening period, the Balling-acid ratio will be high, and the grapes palatable at relatively low sugar. If the weather is cool, the acid will be higher, and more sugar will be required for equal palatability.

Judging Maturity in Picking.—Obviously the picker cannot test each cluster for sugar and acid. In judging maturity he relies chiefly upon the following indications: (1) Color and condition of the stem; if the main part of the stem that attaches the cluster to the cane is brown and woody, or if the stem framework of the cluster is of light straw or yellow color, the grapes are likely to be mature for table use. (2) Taste of the berries; the greenest grapes of a cluster—those near the apex—should be the ones chosen for tast-

[14] Tap water, if reasonably pure, is satisfactory.

[15] The tartaric acid equivalent of ordinary 0.10 normal sodium hydroxide is 0.0075 gram tartaric acid per cubic centimeter.

[16] Sometimes per cent acid, grams acid per 100 grams solution, is used in this calculation. Grams acid per 100 cc is preferred because it is easier to obtain.

[17] Winkler, A. J. Maturity tests for table grapes. California Agr. Exp. Sta. Bul. 529:1–35. 1932. (Out of print.)

ing. Since the sense of taste is quickly dulled by frequent use, the picker must rely principally on other characteristics, using taste only occasionally when he cannot otherwise decide whether or not to pick a given cluster. (3) Appearance of the berries; red or black grapes develop their characteristic color as they ripen. Though a well-colored grape is not necessarily ripe, when grown under the same conditions the best-colored grapes are usually the ripest. Green or white varieties become more nearly yellow or white as they ripen.

Not all the fruit in a vineyard nor even on the same vine ripens at the same time. Usually one must go over the vines three or more times in order to harvest most of the table grapes at the proper stage.

HARVESTING WINE GRAPES

The time for picking wine grapes depends to a considerable extent upon the kind of wine to be made. Grapes for dry wines should be of high acidity and moderate sugar content. Such grapes, therefore, are usually harvested after they test 18° Balling but before they reach 23°. For sweet wines the grapes should be high in sugar and moderately low in acid. Grapes for sweet wines are allowed to attain as high a sugar content as is possible without raisining—usually 24° Balling or more.

For ordinary wines, all the crop is harvested at a single picking. This is the usual practice in California. For fine wines, one may make several pickings in order to get the fruit uniform and all at the best possible stage of maturity. Even when the crop is all harvested at a single picking the clusters that have waterberry or redberry, those that are very green, and especially those that are badly raisined, decayed, or moldy should be separated from the good fruit, since they may spoil a good lot of wine.

The grapes are usually picked into field lug boxes and hauled in them, or in bulk loads, to the winery. The best practice, of course, is to crush the fruit and put it into the fermentation vats as soon as possible. If for any reason the grapes must be hauled a considerable distance or held for more than a few hours before crushing, then they should be picked and handled carefully. Broken and crushed grapes spoil quickly, and the organisms that develop in the spoiled grapes may give the wine a bad odor and a high volatile-acid content. The use of dirty, juice-soaked boxes is always objectionable; and bulk hauling for long distances may be undesirable.

PACKING AND SHIPPING GRAPES

The containers and the methods of packing used for grapes to be shipped to eastern markets have been fairly well standardized. Throughout harvesting and packing, efforts are concentrated toward moving the fruit as rapidly as possible from the vines to the refrigerated cars to reduce deterioration to a minimum.

SHIPPING CONTAINERS

Most of the California table-grape crop is marketed in the so-called "display" grape lug. This package is $5\frac{3}{4} \times 13\frac{1}{2} \times 16\frac{1}{8}$ inches (inside), with its total depth ($5\frac{3}{4}$ inches) made up in two parts—the lower part $4\frac{1}{2}$ inches; the upper part $1\frac{1}{4}$ inches. The lid is nailed on the box with no cleats other than the $1\frac{1}{4}$-inch top section. When one attempts to remove the lid, the entire

top part comes off, leaving the box 4½ inches deep. The box is filled as compactly as possible without damaging the fruit. Though the grapes settle during transit, the removal of the top 1¼-inch section with the lid leaves the remainder of the box completely filled and therefore suitable for display.

Baskets, crates, or lug boxes of other dimensions and also sawdust lugs and kegs are occasionally used in the domestic markets. Sawdust chests measuring $7\frac{3}{4} \times 14\frac{15}{16} \times 18\frac{7}{8}$ inches (inside) are used for export.

For wine grapes shipped fresh to eastern markets the most common lug is $5\frac{1}{16} \times 13\frac{1}{2} \times 16\frac{1}{8}$ inches (inside). When lids are placed on these wine-grape lugs, a cleat $\frac{11}{16}$ inch square is used on each end beneath the lid.

MANNER OF PACKING

Table grapes in lugs are usually packed by the "stems up" method. To make this pack, the box is tilted by placing one end of it crosswise in another box or by placing it on a special bench. Packing may start by laying one or more clusters horizontally in the low end of the box. Filling continues from this end, with all clusters placed nearly upright except those needed to make the bottom of the pack solid. The fruit is occasionally pressed toward the low end as the box is being filled, so that when finished the pack is firm.

To pack a sawdust chest, a strip of paper of suitable width is placed crosswise in the box, with the ends of the paper projecting a few inches above the sides of the box. Then the proper quantity of grapes (usually 32 pounds) is placed in the lined container, stems up or otherwise. Sawdust is shaken into and between the clusters by placing the box on a special vibrator (made for that purpose) while the sawdust is being run into the box from an overhead bin. Only specially prepared grape-packing sawdust is suitable for packing grapes. If the shaking is to be done by hand, ¼ to ½ inch of the special sawdust is placed in the bottom of the box. Then is added a layer of grapes, consisting of about half the total amount that must go into the container. The layer of grapes is covered with sawdust, and the lug is rocked by alternately raising and lowering the ends about an inch, each time allowing the raised end to drop to the bench. This causes the sawdust to settle in among the grapes. Next, the remainder of the grapes are placed in the box as a second layer, into which more sawdust is shaken. Before the lid is nailed in place the projecting ends of the paper lining are laid over the top of the finished pack.

Wine grapes are usually "jumble-packed," the clusters being fitted into the box in the best way possible, but with no regular order of arrangement.

PLACE OF PACKING

Grapes are packed either in the vineyard or in special sheds or houses. Both methods have their merits. Field packing involves least handling and also least delay in getting the grapes into a refrigerated car for shipment. Given an adequate supply of skilled labor, favorable weather, and grapes in good condition, a shipper is likely to find field packing the cheapest and probably the best method. If, on the other hand, there are not enough skilled workmen for both picking and packing, or if the grapes require an unusual amount of trimming, or if the weather conditions are unusually severe, more uniform results may be obtained by repacking in a shed.

HANDLING AND TRIMMING THE CLUSTERS

The picker should grasp the cluster by the stem to remove it from the vine and to hold it up for inspection and trimming. He should cut the stem with a sharp knife or, better still, with picking shears. He should carefully remove all defective berries, particularly those broken or decayed, by cutting (with shears) the stem attaching the berries to the cluster. Under no circumstances should he pull the berry off with his fingers, leaving the wet brush attached to the cluster. The cluster is improved by removing all the undersized or insufficiently colored berries. Since, however, the expense usually makes this work impractical, only the worst of these offtype but sound berries are generally removed. Throughout the handling operations, extreme care should be exercised to avoid crushing any grapes or breaking them loose from the stems. Any break in the skin offers an easy entrance for molds, yeasts, and other decay-causing organisms.

PRECOOLING AND SULFUR DIOXIDE TREATMENT

The sooner the grapes are cooled after being removed from the vine, the better they will be when they reach the market. They may deteriorate as much in one day at a temperature of 85° or 90° F as in a whole week at 45°. The rate of cooling in the refrigerator car with only the normal circulation of air to carry away the heat from the fruit is very slow. Usually 3 or 4 days are required to cool the grapes to below 50° in the top layer of the car. By the use of car precooling fans, or other suitable precooling devices, cooling can be accomplished in 12 to 18 hours. The same results are obtained, but at a higher cost, by warehouse precooling.

If grapes are exposed to sulfur dioxide gas in the atmosphere, they will absorb it. A concentration of 15 to 20 parts per million of sulfur dioxide in sound table grapes greatly reduces the rate of deterioration. Ordinary wine grapes require about 50 parts per million. Under actual operating conditions the best methods of application involve displacing the air in a standard refrigerator car, or in some other treating chamber, with sulfur dioxide diluted with air to a concentration of approximately 2 per cent by volume. The ventilators and doors are then tightly closed, and the grapes absorb the sulfur dioxide from the mixture of sulfur dioxide and air. The chief benefit of the sulfur dioxide is its repressing effect on molds and other decay-causing organisms. It also assists in retaining the green coloring in the stems.

DRYING RAISINS

The clear, warm autumn weather of the middle and upper San Joaquin Valley permits raisins to be dried between the rows of vines in the vineyards, a method commonly known as natural sun-drying. About 85 per cent of the raisins of the state are dried in this manner. Most of the remainder are dehydrated.

TIME TO PICK GRAPES FOR RAISINS

Grapes are usually considered ripe for raisins at 23° Balling or more. With the natural sun-drying process, the riper the grapes the better the raisins and the higher the yield, so long as there is no damage from rain; hence, although

grapes harvested at 23° Balling make good raisins, those allowed to attain 24° or 25° will be even better. The degree of maturity at which to pick is usually a compromise between two considerations: first, the better quality and heavier yield obtained if full ripening takes place; second, the risk of unfavorable drying conditions if the grapes are allowed to hang on the vine too long. The earlier they can be harvested, the greater are the chances of their drying without interference from early fall rains. In the San Joaquin Valley the grapes are usually allowed to attain a minimum of 23° Balling, provided this occurs by the first of September. Most of them should be picked by the middle of September regardless of the sugar content.

With grapes that will be dehydrated, weather conditions are only a minor factor in the drying; further, the influence of maturity on the quality of the raisins is less marked than with the natural sun-dried product. Even for dehydrated raisins, however, the grapes should be at least 21° Balling—preferably, indeed, between 23° and 26°. Harvesting must be completed before the early rains cause deterioration.

SUN-DRYING

The grapes are picked into boxes or pails and then spread evenly on paper or wooden trays (2 × 3 feet), from 20 to 24 pounds of fresh grapes per tray. When the top layer of berries has browned and shriveled (usually about a week later), the grapes are turned upside down onto another tray. When the grapes are two thirds to three fourths dried, wood trays are stacked, and paper trays are rolled. The raisins are allowed to continue drying in the stacks or rolls. When they have reached the point where juice can no longer be squeezed out—16 per cent moisture or less—they are packed tightly into sweat boxes and hauled to central processing and packing plants.

To prepare a good place for the trays, the spaces between the rows in the vineyard are smoothed and leveled. Usually with a light crop the space between two rows will furnish enough room in which to dry the fruit from both, leaving the alternate space unobstructed; but with a heavy crop every space is needed. If the rows in the vineyard run north and south, one need merely level and smooth the space; but if they run east and west, the bed is best prepared so that it slopes to the south and thus exposes the grapes more directly to the sun to hasten drying. East-west direction of rows is preferred for rapid drying.

The three important raisin varieties—Thompson Seedless, Muscat, and Black Corinth—all may be dried by this method. The Black Corinth, however, ripens very early and, if the weather is hot, is best dried on stacked wooden trays with little or no direct exposure to the sun.

DEHYDRATION

In the San Joaquin Valley north of Madera County and in the lower Sacramento Valley, where temperatures are lower, the grapes ripen later than in the middle and upper San Joaquin, and early fall rains are more common. In these districts it is somewhat hazardous to dry the raisins in the vineyard without pretreatment. Dehydrators are being used to a considerable extent, producing the golden bleached raisins. First the grapes are dipped into a solution containing 0.2 to 0.5 per cent lye (sodium hydroxide) at a temperature

near boiling. Then they are rinsed by spraying with cold water. The length of the hot dip—usually 1 to 5 seconds—depends upon the strength of lye, the temperature, and the maturity of the fruit. The grapes are dipped until very faint checks show in the skins after the cool rinse. After dipping, they are spread on trays and exposed to the fumes of burning sulfur until the green color has bleached to a yellowish white, usually 2 to 4 hours. Then they are dehydrated at 140° to 160° F. The product—a light, brilliant, golden yellow—is very attractive. As the raisins taste strongly of sulfur dioxide, they are unpalatable for eating out of hand; but when they are used in cooking or baking, the sulfur dioxide disappears to the extent that it is neither noticeable nor harmful. The golden-bleached product of California competes in foreign markets with the Sultana raisins of Australia and the Smyrna raisins of Asiatic Turkey. Though the quality is inferior to that of the Sultana, the cost of production is much lower.

DISEASES AND PESTS[18]

California is free from many of the serious fungus diseases and insect pests that trouble the industry elsewhere. Several, however, are present and must be controlled for successful operation of a vineyard.

POWDERY MILDEW[19]

Powdery mildew, also called oidium in other grape-growing regions, is caused by a fungus that may grow on all green parts of the vine. It appears on the surface of affected parts as a grayish-white, powdery growth, which, when rubbed off, leaves weblike black or dark-brown discolorations. It causes curling and withering of the leaves in spring and early summer; dropping, discoloration, or splitting of the berries; blackening and poor maturity of the canes. It is present in every grape-growing region of the state. The seriousness of the disease depends upon the weather, unless the trouble is artificially controlled. Measures to control powdery mildew should be taken in all seasons and in all regions except perhaps the hot desert. As a preventive measure, the vines are dusted with finely divided sulfur, usually by means of knapsack or power machines. If, however, only a few vines need be dusted, the sulfur may be placed in a coarse cloth bag, which is then shaken on the windward side of each vine so that the cloud of sulfur formed will drift over and through. Dusting wet vines, or when the temperature is over 100° F, should be avoided.

The following schedule of dusting is recommended for conditions favorable to powdery-mildew development:

1. *First dusting*, 5 to 7 pounds of dusting sulfur per acre, when the vine shoots are 6 to 8 inches long. This application is very essential. It is made irrespective of temperature and repeated after heavy rains.

2. *Second dusting*, 5 to 7 pounds of dusting sulfur per acre, when the vine shoots are 12 to 15 inches long.

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[18] The assistance of W. B. Hewitt, Assistant Professor of Plant Pathology, and L. M. Smith, Associate Entomologist in the Experiment Station, in the preparation of this section is gratefully acknowledged.

[19] For a more complete discussion see: Jacob, H. E. Powdery mildew of the grape and its control in California. California Agr. Ext. Cir. 31:1–17. 1929. (Out of print; may be consulted at many city and county libraries in California.)

3. *Third dusting*, 8 to 10 pounds of dusting sulfur per acre, 14 days after the second dusting. This will be about blooming time.

4. *Fourth dusting*, 10 to 15 pounds of dusting sulfur per acre, 14 days after the third dusting.

5. *Fifth dusting*, 10 to 15 pounds of dusting sulfur per acre, when the berries are about one-half grown.

6. *Sixth dusting*, 10 to 15 pounds of dusting sulfur per acre, just before the grapes begin to ripen.

Most American or slipskin varieties are resistant enough so that they seldom need dusting. All European varieties are susceptible; and for good control all such varieties grown in the coast sections and most of the table-grape varieties in any section, except the hot desert regions, should receive all six dust applications. On raisin and wine-grape varieties in the interior valleys of California, satisfactory control has been obtained with a dusting program in which the fourth and sixth applications are omitted. In the hot Coachella and Imperial valleys one application, when the shoots are 15 to 18 inches long, may suffice.

If, for any reason, powdery mildew becomes conspicuous, it cannot be cured by dusting with sulfur. A liquid eradicant spray may then be advisable. Such sprays spot or stain the fruit and are usually objectionable, especially on table grapes. The spray recommended for early-season outbreaks consists of ½ gallon liquid lime-sulfur, 5 pounds of wettable sulfur, and suitable spreader, per 100 gallons of water. Later in the season, less objectionable residue is deposited from a mixture of 1⅓ pounds of potassium permanganate, 1⅓ pounds of sodium silicate, and ½ pound baking soda per 100 gallons of water. Within 2 days after being sprayed, the vines must be dusted with sulfur to prevent a recurrence of the mildew.

BLACK KNOT

The organisms (bacteria) that cause crown gall on trees and shrubs produce black knot on grapevines. The growth of the bacteria causes a proliferation of the cells in the local area of attack; then follow spongy swellings, at first greenish brown, which later die and become black (whence the name). The disease is most prevalent on vines injured by winter freezing. As it seldom causes serious damage, little or no effort at control is usually made except to avoid cutting into the galls with pruning tools or any other implements that will later be used on healthy tissues. The simplest method of killing the galls, if one desires to do so, is to spray or swab with a sodium arsenite solution made up as described for the control of black measles.

PIERCE'S DISEASE OF GRAPEVINES[20]

This very destructive disease was first observed in 1884 in southern California, where it was called Anaheim disease, California vine disease, mysterious vine disease, and vine plague. Attempts to replant vinifera-grape varieties in southern California localities where the disease killed out the vineyards have

[20] This disease is more fully discussed in: Hewitt, Wm. B., Norman W. Frazier, H. E. Jacob, and J. H. Freitag. Pierce's disease of grapevines. California Agr. Exp. Sta. Cir. 353:1–32. 1942.

been unsuccessful; the vines die within three or four years after planting. The trouble is now known to be present in every important vineyard district of the state, and in local areas it has occasionally assumed epidemic proportions. The total losses resulting are difficult to estimate; they vary from a few scattered vines in some affected vineyards to nearly complete destruction of other plantings. The future course of Pierce's disease is unpredictable.

The cause is a virus that is transmissible from diseased plants to healthy ones. The same virus causes alfalfa dwarf. Many other plants are also hosts to the disease, including Ladino clover, red clover, white and yellow sweet clovers, several grasses, and some shrubs. The presence of infected alfalfa and clover fields is a serious threat to grapevines nearby. Three species of insect vectors (sharpshooter leafhoppers, not the grape leafhopper) apparently cause most of the spread in vineyards. The disease may also be carried, to a limited extent, in buds (for grafting) and in cuttings taken from diseased vines.

The characteristic symptoms observable in early summer include delayed starting of growth, leaf mottling, and dwarfing of the new shoots. In late summer and fall the diseased vines show burning, scalding, or drying of the leaves; wilting or premature coloring of the fruit; uneven maturity of the canes. Diseased vines die in two or more years, the length of life after infection depending mainly on the grape variety and the age of the vines. Ribier usually dies within two years; Emperor, Malaga, Thompson Seedless, and most other vinifera varieties in two to five years. Some of the American (slip-skin) varieties live much longer.

No fully effective control of Pierce's disease is known, nor any treatment that will prolong the life of diseased vines. To maintain the vineyard in production and, sometimes, to slow the spread of the disease, one should remove all diseased vines found and replant with healthy vines or with layers from adjacent healthy vines. The disease is not carried over in the soil to the new vine.

BLACK MEASLES

The names black measles, Spanish measles, and black mildew are applied mainly to a peculiar speckling of white or red grape skins with reddish brown or purplish spots. Sometimes the skins are mottled. The fruit of severely affected vines often cracks and splits open; it may dry up on the vine before maturing.

Severe fruit symptoms are usually, but not always, accompanied by discoloration and dropping of leaves and dying back of the shoot tips. The leaves of affected vines develop various degrees of mottling, bronzing, spotting, and death of tissue between the leaf veins. The discolored leaf areas may enlarge into yellow spots, which later dry up and turn brown or red. These symptoms are usually most prominent in late summer, but may occur at any time during the growing season. An entire vine may be affected, but commonly the symptoms are found on a single arm or branch. Measles may show in some vines one season and not the next, but badly diseased vines usually manifest the symptoms every year. In some vines the disease appears suddenly; these vines may dry up and entirely drop their leaves within a few days, and some will die; but many will start new growth again within a few weeks. Vines ten to

fifteen years old or older are most often affected, but some others have been attacked at only three years. The cause of the disease is not known.

To control black measles, one should spray or swab the trunk and arms during the dormant season with a solution of sodium arsenite[21] containing the equivalent of 2.7 pounds of arsenic trioxide to 100 gallons of water. Special care should be taken to wet all old wounds thoroughly. The treatment is applied only after the vines have become completely dormant. Complete dormancy for this purpose may be interpreted as meaning 3 weeks after the first killing frost. Experience has shown that in seasons when the vines do not become fully dormant it is best to delay treatment for another year. The spray may be applied either before pruning—but at least 3 weeks after the first killing frost—or at least 3 weeks after pruning—but before the buds swell in the spring. If a power spray machine is used, the pressure should not exceed 100 pounds.

Sodium arsenite is very poisonous, and extreme care must be taken to keep it away from people and animals and to avoid getting it on the skin or in the mouth and nose of the persons applying the spray. Since the material is so extremely poisonous and, if applied improperly, may injure the vines, those contemplating its use are urged first to consult their local farm advisor or someone else thoroughly familiar with the procedure, and to work under his direction.

ARMILLARIA ROOT ROT (OAK-ROOT FUNGUS)

Oak-root fungus, apparently native to California, occurs in several vineyard areas of the state. It causes a rot of roots and trunks of many trees and shrubs as well as of vines. The first indication of its presence is usually a decline in vigor; growth stops and the foliage turns yellow. In following seasons, as a rule, cane growth is weak and the leaves are small. The vines often die suddenly after displaying some of these signs. White, fan-shaped plaques of the fungus can usually be found spreading between layers of the bark and between the bark and the wood. Infected roots and underground trunks may have small, black, somewhat smooth and shiny, threadlike strands on the surface and penetrating into the bark. In the fall and winter, after the rains start, clumps of mushrooms may also appear at the base of affected vines.

Soil treatment with carbon disulfide is the most promising remedy. The expense, though considerable, is warranted in vineyards that have relatively small infected areas. Application should be made when the soil is fairly dry, as in summer or early fall. The area to be treated should be cleared by removing all vine trunks and roots to a depth of 12 inches. The surface should be cultivated and pulverized to form a loose mulch. Then it is wetted 2 or 3 inches deep, by sprinkling or spraying with water, to form a seal which will prevent escape of the gas. While the surface is still wet, the carbon disulfide is injected 6 to 8 inches deep, in holes 18 inches apart, which are staggered in rows 18 inches apart. Two ounces by weight (1¾ ounces by volume) of carbon disulfide are used in each hole. Each hole is plugged with soil and packed with the heel of the shoe immediately after the injection is made; packing the entire

[21] Sodium arsenite for this purpose is usually sold as a heavy solution containing 4 pounds of arsenic as arsenic trioxide (As_2O_3), the equivalent of 6 pounds of sodium arsenite, per gallon. For each 100 gallons of spray, use ⅔ gallon of such material. No spreader is needed.

surface by dragging, rolling, or tamping makes the treatment more effective. Then, re-wetting the surface by sprinkling or spraying completes the treatment.

The treatment outlined should kill the fungus to a depth of 5 or 6 feet in sandy or loam soil. If the vine roots go deeper, the dosage should be increased accordingly. The treated areas may safely be replanted the following spring.

The effectiveness of this treatment is hard to determine until three or more years after replanting. In some vineyards where the method has been used, parts of the area have had to be re-treated. In other vineyards, diseased vines showing at the margins of the treated plots indicate that the original application did not include all the affected vines.

LITTLE-LEAF

As the name implies, vines affected with little-leaf disease have small leaves, especially toward the shoot tips and on lateral shoots. The leaves in midsummer become variegated or mottled; the tissue close to the veins is the greenest, and the interveinal areas are whitish or yellowish green. The color differences vary from inconspicuous to very pronounced. In severe cases the leaves are distorted and asymmetrically formed. The deformity shows particularly at the base of the leaf where the stem or petiole is attached to the blade. Here the veins fail to spread out, and the leaf lacks the deep petiolar sinus, or indentation, it would normally have. In severe cases the veins become gathered together, and the leaf resembles a partly opened fan. The canes of vines affected by little-leaf often produce numerous lateral shoots which have short internodes and very small leaves; these give the vine a brushy appearance.

The crop is diminished even on vines that are only slightly affected; the clusters tend to be straggly and have many small, round, seedless (shot) berries. Badly affected vines may produce little or no normal fruit.

Cure or control consists in applying zinc. With spur-pruned vines, the best remedy is to paint or swab the pruning cuts at the ends of the spurs, within a few minutes after pruning, with a solution of 2 pounds of zinc sulfate to a gallon of water. On cane-pruned vines this treatment, though sometimes helpful, has not proved adequate; but no other method tried has given better results. Treatment early in the winter appears to be more effective than later (after the vines begin to bleed). Sometimes, especially when zinc has been applied in cold weather, with the soil very dry, buds on many spurs have been injured or killed.

PHYLLOXERA[22]

In California, phylloxera, an insect related to and resembling the aphids, attacks only the roots of grapevines. It causes serious trouble, for, once a planting is infested, little or nothing can be done, and the vines usually die out in three to ten years. On the young rootlets, the feeding of the insects causes small swellings, and these give a contorted (hooked) appearance and check the growth. On the larger roots small galls are formed, which later decay and disrupt the functioning.

[22] A thorough discussion of this insect and its life history may be found in: Davidson, W. M., and R. L. Nougaret. The grape phylloxera in California. U. S. Dept. Agr. Bul. 903: 1–128. 1921. (Out of print; may be consulted at many city and county libraries in California.)

Control consists in grafting the fruiting varieties on rootstocks resistant to phylloxera. Establishment of such vineyards is discussed under propagation.

Once an area becomes infested, it remains so as long as any grapevines survive. In infested areas own-rooted (ungrafted) vines of vinifera varieties cannot be grown except on very sandy soils. The American varieties have varying degrees of resistance. In sandy loam and heavier soils the phylloxera is more serious and spreads more rapidly than in sandy soils. Vines growing in soil so sandy that it does not crack when dried after a thorough wetting are unlikely to be attacked.

Infested Areas.—Southern California is still relatively free from phylloxera. In the San Joaquin and Sacramento valleys, Stanislaus, Merced, and Tehama counties are free; and Kern, Kings, and Madera counties have only localized areas of infestation. Phylloxera-resistant stocks are required in and adjacent to the infested areas. The farm advisor or the agricultural commissioner may be consulted for information regarding danger zones. San Joaquin County and the entire Sacramento Valley, with the exception of Tehama County, have many local areas of infestation; in the older vineyard areas phylloxera-resistant rootstocks are advised for loam and heavier soils. New lands not adjacent to other vineyards and not irrigated with river or creek water may be planted to own-rooted vines with reasonable safety. Fresno and Tulare counties have large areas of general infestation, particularly east of the city of Fresno and in the Dinuba-Cutler-Yettem area. Many other smaller danger zones occur. Although these two counties still contain large areas of uninfested land, any grower planting vines on soils of sandy-loam or of heavier texture is advised to investigate the probable danger. If no phylloxera is present within a half mile, he will probably get the best vineyard from rootings of the desired fruiting variety. If phylloxera occurs in his soil or in an adjacent vineyard, resistant rootstocks are advised. The entire north coast region (except parts of San Benito County) is widely infested; resistant rootstocks are therefore generally required and are advised for all new plantings in the coastal valleys and adjacent rolling lands.

Rootstock Varieties.—Most rootstock varieties are hybrids, artificially produced by crossing two or more grape species. A very small number are selections from wild vines. Hundreds exist, but only a few varieties are used commercially in California.

Rupestris St. George is the standard phylloxera-resistant stock for wine-grape varieties on the nonirrigated soils in the coastal valleys of California. Under these conditions it is recommended, and is used almost exclusively. It is not resistant to nematodes.

Aramon × Rupestris No. 1, in irrigated soils that are free from nematodes, usually surpasses St. George in growth and productivity of the grafted vines. It is less resistant to phylloxera than St. George and is even more susceptible to nematodes than most of the fruiting varieties. Commercially it appears to be the best stock available for wine-grape varieties in irrigated loam soils of the great central valley of California. It also does well in deep, moist soils in the coastal valleys, but it is not recommended for dry hillside land. In the sandy, nematode-infested soils found in the San Joaquin Valley, it is practically worthless.

Solonis × Othello 1613 is moderately resistant to phylloxera and highly resistant to the root-knot nematode. In fertile, irrigated, sandy-loam soils in the San Joaquin Valley it is usually the best rootstock available. It is not known to be incompatible with any variety except, perhaps, Ribier. In non-irrigated soils and in very poor sandy soils the grafted vines are likely to be weak and unproductive; in loam and heavier soils they are not equal to the Aramon × Rupestris No. 1 stock in vigor and productivity, but are often superior in the quality of their table grapes.

Dogridge and Salt Creek are extremely vigorous nematode-resistant rootstock varieties. They are available only in limited quantity. Being still in the experimental testing stage, they should be tried only in very sandy soil of low fertility where vines on Solonis × Othello 1613 are too weak to give satisfaction. In fertile sandy or sandy-loam soils the vines often grow with such extreme vigor that they are unproductive.

NEMATODES

Nematodes are small worms that live on the surface of the roots or bore into the roots and live there. Of the several varieties that attack grapes, the root-knot, or garden, nematode is the most common. It causes, on the roots, swellings and distortions which may sometimes be mistaken for phylloxera. Though apparently all vinifera grapes are susceptible, varieties differ slightly in the extent of nematode injury. Thompson Seedless will do fairly well in some places where Red Malaga and Ribier are failures.

In very sandy soils heavily infested with nematodes, one may find it impossible to grow grapes except by using nematode-resistant rootstocks. Loam and clay-loam soils are not often seriously affected. Resistant rootstock varieties are discussed in the section on phylloxera.

GRAPE LEAFHOPPER[23]

During certain periods the grape leafhopper has severely injured the vineyards of the San Joaquin Valley and of other regions. It appears to increase and decrease in cycles. The insect is whitish green, about $\frac{1}{10}$ inch long, with red markings in the adult form. It injures the leaves by sucking their juices and causing minute round, whitish spots to appear on the leaves. When abundant, it causes the leaves to drop prematurely. It also soils the fruit with the black specks of its droppings. There are usually two or three broods in the season, with the insects overwintering in the adult stage.

The materials listed below, when properly used, give good control.

Pyrethrum.—In the early spring, after the green shoots appear, the overwintering adults seek them to feed and to lay eggs. At this time, one may kill them and in isolated vineyards accomplish effective control by spraying with an oil solution of pyrethrum; special "vapo-spray" equipment should be used but not an ordinary spray rig. Only about 3 gallons is required per acre. The spray must be applied as soon as the overwintering adult leafhoppers have migrated into the vineyard—that is, about 10 days after growth starts in the spring.

[23] This insect, its life history, and some methods of control are completely discussed in: Lamiman, J. F. Control of the grape leafhopper in California. California Agr. Ext. Cir. 72:1–20. Reprinted 1937.

Nicotine.—The wingless nymphs of the first brood appear in May and early June. Just as the oldest nymphs are growing wings, the vines may be treated with a spray consisting of 1 to 1½ pints of nicotine sulfate (40 per cent) per 100 gallons of water, together with an appropriate spreader, such as soap. The effectiveness of the spray is increased by adding ¼ pound of lye per 100 gallons to make it alkaline. In the application, care must be taken to wet the hoppers on the lower side of the older leaves. To do an effective job, one must direct the spray from the nozzles upward.

Calcium Cyanide.—Late in the season, when most of the hoppers are adult and very numerous, treating the vines with calcium cyanide dust is effective. This dust should be applied with power machinery, and the weather conditions must be favorable—that is, without wind and with fairly high humidity. In the San Joaquin Valley such conditions are most frequently obtained in the early part of the night.

Since calcium cyanide dust produces a poisonous gas, it should be handled with care. The operators of the dusting equipment should wear adequate gas masks.This material should not be applied with horse-drawn dusting machines, nor in the immediate vicinity of farmyards containing poultry or livestock.

DDT.—A dust containing 5 per cent DDT and 50 per cent sulfur, applied before blossoming and used at the rate of 20 pounds per acre (1 pound per acre actual DDT), kills all remaining overwintering hoppers; and it deposits, on the leaves, a residue that kills the young hoppers when they hatch. Since, however, its use is still experimental, no general recommendation of it can be made until further information is available. Because of the possibility of toxic residue on the grapes, DDT should not be used after blossoming. DDT also is effective when applied as a 1.2 per cent solution in oil at the rate of 3 to 4 gallons per acre with vapo-spray equipment.

CUTWORMS

Cutworms, the larvae of certain night-flying moths, usually remain in the ground during the day but come up the vines at night to chew off the opening buds or the tender young shoots. One can control them by putting a ring of permanently sticky material around the base of each fruit spur or fruit cane, and also around trellising stakes or other objects up which they might climb. A heavy dusting of the trunk and branches with 5 per cent DDT dust, when the buds are breaking, appears also to be effective.

RED SPIDER

The Pacific mite, or red spider, has been very injurious in certain localized areas in the lower San Joaquin Valley, the intermediate central valley region, and the north coast region. The adults, having overwintered beneath the rough bark on the trunks and arms of the vines, emerge in the spring and migrate to the new shoots. As the season advances, the population increases, so that by midsummer or late summer the mites may injure the vines severely, even causing the leaves to drop before the fruit is ripe. Weather and general environmental conditions that favor or hinder the growth of the vines have, apparently, considerable influence on the development of the mites and the seriousness of the damage.

Three possible methods of control are: (1) banding followed by suckering; (2) spraying with oil; (3) dusting with DN (dinitro-*o*-cyclohexylphenol) dust. In banding, a complete circle of permanently sticky material is placed around the base of each spur or fruit cane in February. Suckering is done as needed to prevent bridging to parts above the band by shoots originating below the band, on which the mites collect. The suckers are placed in a pail or paper bag to be carried out of the vineyard and destroyed. For spraying, a 1½ per cent petroleum oil emulsion, U.R. 90 and viscosity 65 to 75, plus a suitable spreader, is applied when the new shoots have 5 or 6 leaves. The spraying is repeated 10 days later. Thorough wetting is essential. Dusting is done with DN dust when the first yellowed spots, caused by the mites, are found on the leaves. Special dusting machines are needed for a satisfactory job, and 30 to 35 pounds of the dust per acre are used on medium-sized vines; this dusting is repeated if many live mites can be seen on the leaves a week or 10 days after the first application. The dusting must not be done when the weather is hot (95° F or above) or the vines may be injured. A new material—hexaethyl tetraphosphate—now under investigation offers considerable promise.

GRAPE LEAF ROLLER

Sporadic occurrences of the grape leaf roller have sometimes assumed serious proportions. The presence of the insect in a vineyard may be detected by the characteristic rolling of the leaves, one edge being rolled up rather tightly to about halfway across, making a tube (somewhat less than the diameter of a lead pencil) in which the insect lives. In the middle San Joaquin Valley there are apparently three broods a season.

Control is obtained by spraying with 4 to 6 pounds of lead arsenate and 5 or 6 pounds of wettable sulfur per 100 gallons of water just before the grapes blossom in the spring, then dusting with 40 to 50 per cent cryolite sometime during the blooming period. The second brood may be controlled with cryolite dust in July, but dusting so late as this may leave a poisonous residue on the fruit. Suckering of the vines in the spring may remove as many as one third of the eggs.

RABBITS

In newly planted vineyards and in young vineyards, rabbits are often destructive. They come back to the same spot night after night, eating off the leaves until, eventually, the vines are killed or weakened severely. The most effective control method is to fence the young vineyard with rabbitproof wire netting 2½ feet high above the ground and extending a few inches into the ground. If the rabbits are not very numerous and if only occasional vines are attacked, these vines may be sprayed with deer repellent, which will cause the rabbits to avoid them. Slaughterhouse blood is sometimes effective when spattered on stakes, clods, and other objects near the vines.

GOPHERS

Young vines may be girdled by gophers just below the surface of the ground. These pests may be trapped or poisoned by conventional methods. Information can be obtained from the office of the county agricultural commissioner or from the farm advisor.

THE GRAPE VARIETIES[24] OF CALIFORNIA

Probably 6,000 to 8,000 varieties of grapes have been named and described. In California about 10 per cent of this number are growing somewhere in the vineyards, gardens, and variety collections, though not more than 40 or 50 can be considered as important commercial varieties.

In the following paragraphs an attempt has been made to give the purpose, importance, and adaptability of each of the most common commercial varieties of raisin, table, and wine grapes now being grown in California. A brief horticultural description is included; but long, detailed, technical accounts have been purposely avoided. The photographs in figure 23 illustrate various berry shapes.

RAISIN GRAPES

Thompson Seedless (Sultanina).—Well over half the world's raisins and about 80 per cent of California's are made from Thompson Seedless which originated in Asia Minor and was first grown in California by Mr. William Thompson near Yuba City. It is called Oval Kishmish in the eastern Mediterranean regions, Sultana in Australia and South Africa.

In California about one third of the total grape acreage is Thompson Seedless. Besides being the principal raisin variety it is the leading table grape; but for the production of table grapes the vines are usually girdled to make the berries larger and to improve shipping quality. From it are also made large quantities of white dessert wines and much distilling material to furnish alcohol for the fortification of other dessert wines.

The clusters are large; heavily shouldered, long cylindrical; and well filled. The berries are uniform, medium-sized; ellipsoidal elongated; greenish white to light golden; always seedless; firm and tender in texture; neutral in flavor; very sweet when fully ripened; and moderately tender-skinned. As the berries are somewhat weakly attached to the stems, causing the clusters to "shatter" in transit, the shipping quality of the fresh grapes is only fair. The ripening period is early midseason. The grapes dry easily into raisins of soft texture and excellent quality. The vines are very vigorous and very productive. Cane pruning is required.

The Thompson Seedless is well adapted to all parts of the San Joaquin Valley where grapes are grown and to the warmer parts of the Sacramento Valley. In the hot desert it does better than any other variety tried. It is unsuited to the cooler regions.

A pink variation—Sultanina rose—is of interest for home use. Except for its pink, or rose, color it is almost identical with the Thompson Seedless.

Muscat of Alexandria.—The Muscat of Alexandria is a very old variety of North African origin, from which are made the raisins of Spain—the cluster Malagas and the stemmed Valencias or Muscatels. Muscat accounts for about 15 per cent of the California production of raisins, and it is also an important raisin variety in Australia.

As a table grape it is highly esteemed for home gardens and local markets. Its delicious flavor, large size, and juicy, but not watery, pulp make it a

[24] The popular name in California is given first. The name in parenthesis is the name most commonly used elsewhere in the world.

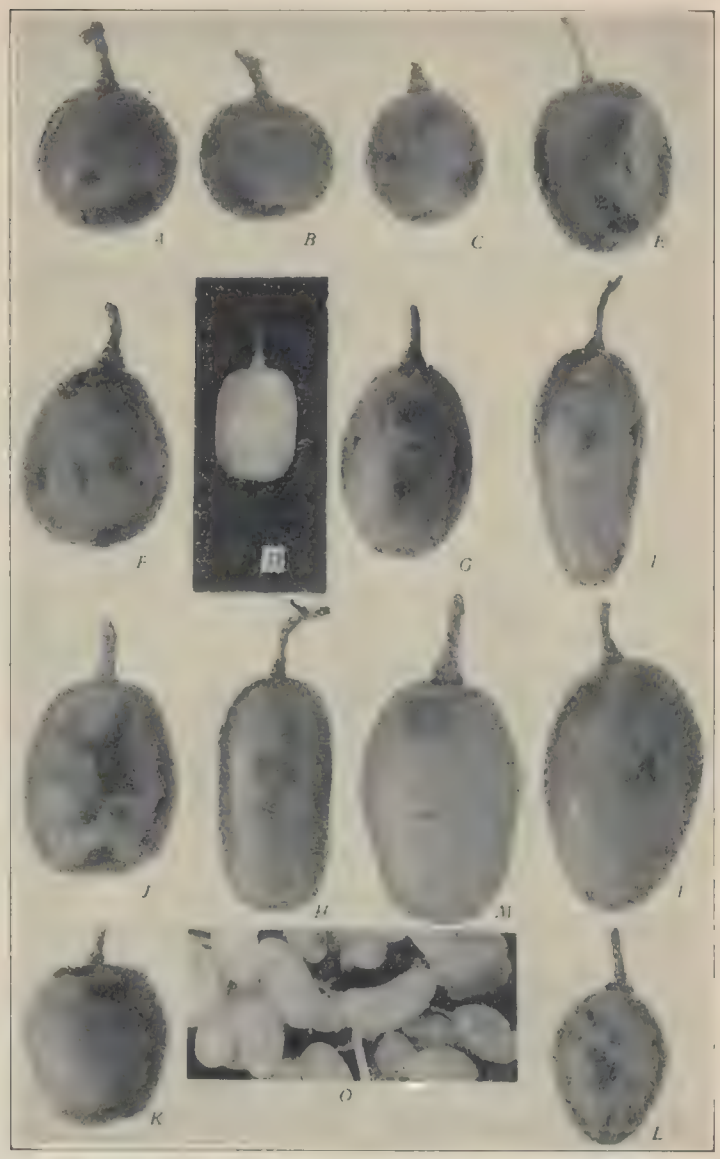

Fig. 23.—Grape berry shapes: *A*, spherical; *B*, oblate; *C*, ellipsoidal; *D*, cylindroidal; *E*, ovoid; *F*, obovoid; *G*, ellipsoidal elongated; *H*, cylindroidal elongated; *I*, ovoid elongated; *J*, obovoid elongated; *K*, ovoid truncated; *L*, ovoid pointed; *M*, fusiform; *O*, falcoid elongated. (From Hilgardia vol. 11, no. 6.)

favorite with nearly all who are familiar with it. Although it has fair shipping qualities, the bloom is easily rubbed off in handling, leaving exposed its dull-green ground color. It lacks the attractive appearance necessary to stimulate sales of any fresh fruit and is therefore relatively unimportant in table-grape shipments to eastern markets.

As a wine grape the Muscat of Alexandria is extensively used for muscatel, a dessert wine. Much of the crop is used for this purpose. Dry wines made from it are mediocre or inferior.

The clusters are medium-sized; shouldered, conical; and loose, often straggly. The berries are large, obovoid, dull green, normally seeded, pulpy, and strongly aromatic (Muscat) flavored. The moderately tough skins are covered with a gray bloom, easily rubbed off. The ripening period is late midseason, and the grapes dry easily into large raisins of soft texture and excellent quality. The vines are medium in vigor and are very productive; they are usually head-pruned. In some regions and in many soils the flowers set poorly; the results are straggly clusters, many shot berries, and, frequently, poor crops. Often the setting of the flowers can be improved by painting the pruning wounds with zinc sulfate as recommended for little-leaf, or by longer pruning and flower-cluster thinning.

The Muscat of Alexandria is adapted only to hot regions. It thrives in most of the grape-growing areas of the San Joaquin Valley, the warm parts of the Sacramento Valley, and the warm valleys of the south coast region. It is not suited, however, to the hot desert because of its tendency to sunburn under conditions of extreme heat.

A pink variation—Flame Muscat—unimportant in California, is grown in South Africa under the name Red Hannepoot.

Black Corinth (*Zante Currant*).—For over five hundred years Zante currant raisins have been made in Greece, where the variety probably originated and where most of the world's supply was produced.

The clusters are small to medium in size; winged, uniformly cylindrical; well filled to compact when the vines are girdled, but straggly on ungirdled vines. The berries are very small; spherical to oblate; reddish black; mostly seedless, with an occasional seeded berry of medium size; very juicy; neutral in flavor; and have very thin and tender skins. They ripen early and dry easily into very small raisins of soft texture and pleasing tart taste.

The vines are vigorous and—if girdled—productive. They may be cane- or cordon-pruned.

The Black Corinth is well suited to the central and lower parts of the San Joaquin Valley. It has also done very well in experimental plantings at Davis.

Seedless Sultana (*Round Seedless*).—This grape resembles the Thompson Seedless but differs in having smaller, spherical or oblate berries, a few of which contain partly hardened seeds. It has been largely displaced by the Thompson Seedless.

TABLE GRAPES

Thompson Seedless.—For discussion of the Thompson Seedless variety, see "Raisin Grapes."

Flame Tokay.—Formerly the Flame Tokay was California's premier table-grape variety. It is now surpassed by both the Thompson Seedless and the

Emperor. It owes its importance primarily to its brilliant red color and to its good shipping and keeping qualities.

The variety apparently originated in Kabylia, a province of Algeria, where it is known by the Arab name of Ahmeur bou Ahmeur.

The clusters are large; shouldered, short conical; and compact. The berries are large to very large; ovoid truncate; brilliant red to dark red; normally seeded; very firm; neutral in flavor; and have thick, fairly tough skins. The stems are large and tough, and the berries adhere firmly. The grapes ripen in late midseason. They are sensitive to sunburn. The vines are usually head-pruned.

The principal producing area is around Lodi, in the intermediate central valley region. There are other areas of lesser importance in Sacramento County, and a few scattered commercial plantings elsewhere in the state. In the hotter regions the variety does not color well and sunburns badly, whereas in the cooler coastal sections it does not ripen well.

Emperor.—The origin of the Emperor is unknown. Second in popularity as a table variety, it owes its importance to its late ripening, its attractive appearance, and its excellent shipping and keeping qualities. Large quantities are held in cold storage to extend the marketing season.

The clusters are large in size; long conical; and well filled. The berries are uniform, large; elongated obovoid or ellipsoidal; light red to reddish purple; normally seeded; moderately firm; neutral in flavor; and have thick and tough skins. The stems are tough, and the berries adhere very firmly. The variety ripens late. The vines are very vigorous and productive. They are cordon-pruned; often short cordons are supplemented with short fruit canes at the ends of the branches.

The Emperor is profitable only when it attains a red color and a large berry size. It most nearly attains perfection near the foothills along the east side of the San Joaquin Valley in Tulare and Fresno counties. About 90 per cent of the commercial Emperors are produced in this area.

Malaga.—The Malaga, once California's leading table-grape variety, has been largely replaced in the market by the Thompson Seedless (from girdled vines). As a table grape the Malaga now occupies a relatively minor position, and most of the production is used for distilling material or low-grade wines.

The clusters are large to very large; conical; and well filled. The berries are uniform, large; ellipsoidal; whitish green to whitish yellow; normally seeded; firm; neutral in flavor; and have thick, moderately tough skins. The stems are tough, and the berries adhere firmly. Shipping and keeping qualities are very good. The vines are vigorous and very productive. Although cordon pruning is best, head pruning is satisfactory. The ripening time is midseason.

The Malaga, being suited only to the warmer regions, is grown in various parts of the San Joaquin Valley.

Red Malaga (Molinera).—The Red Malaga is a Spanish variety grown in Spain under the names Molinera Gordo and Castiza. In California, where it ripens earlier than the Flame Tokay, it provides the market with a red table grape suited to warmer regions.

The clusters are very large; widely branched and irregular in shape; and loose to well filled. The berries are large; spherical to short ellipsoidal; pink

to reddish purple, often faintly striated; normally seeded; very crisp and hard; neutral in flavor; low in acidity; and tender-skinned. The stems are tough; the berries are firmly attached. Shipping and keeping qualities are fair. The vines are very vigorous and productive when cordon-pruned or long-pruned and flower-cluster-thinned. The grapes ripen in midseason, usually just prior to the Malaga.

The Red Malaga is well suited to most of the San Joaquin Valley, where it ripens earlier and can be marketed before the Flame Tokays of the intermediate central valley region. After the Tokays start to move, the demand for Red Malaga rapidly decreases.

Ribier (*Alphonse Lavallée*).—This beautiful table grape, misnamed Ribier in California, is one of the finest of the European hothouse varieties; the grape grown in California is the Alphonse Lavallée and not the Gros Ribier of Europe. Although it is the principal black table grape in the state, in total production it ranks only sixth among all table-grape varieties.

The clusters are medium in size; short conical, often heavily shouldered; varying from loose to compact. The berries are very large; oblate to ellipsoidal in shape; jet black; normally seeded; firm; neutral in flavor but mildly astringent; low in acid; and moderately tough-skinned. The stems are tough, and the berries firmly attached. The shipping quality is good; the keeping quality excellent. The vines are moderately vigorous and very productive. They are cordon-pruned. The fruit ripens in midseason.

The Ribier is best suited to the warm middle and upper San Joaquin Valley.

Almeria (*Ohanez*).—Spain produces and exports large quantities of Almeria, a late table grape, packed in granulated cork. The variety is not of great importance in California because of its susceptibility to Ohanez spot, apparently a form of heat injury.

The clusters are medium or medium large; short conical; and well filled to compact. The berries are medium large; cylindroidal; greenish white; normally seeded; firm; neutral in flavor; and have thick and tough skins. The stems are tough, and the berries firmly attached. Shipping and keeping qualities are excellent. The vines are vigorous, and usually productive when they are allowed to develop large size and are cane-pruned. The variety does best when trained on arbors. Artificial pollination may sometimes be needed. The fruit ripens late.

The Almeria has been successful only in local areas in Tulare County, on the east side of the San Joaquin Valley.

Cornichon (*Olivette Noire*).—The production of Cornichon has gradually decreased until now it has only a minor importance.

The clusters are medium to large; conical, often winged; and well filled. The berries are large; ellipsoidal elongated; reddish black with abundant bloom; soft and juicy; neutral in flavor; and have thick, tough skins. The shipping and keeping qualities are only fair. The vines, though vigorous, tend to bear irregularly. The fruit ripens in late midseason.

The Cornichon does best in the intermediate central valley region.

Olivette Blanche.—The very large size and regular, elongated shape of the Olivette blanche make it one of the most beautiful of table grapes. Because of its poor shipping quality, it is of only minor commercial importance.

The clusters are very large; irregular conical; and well filled. The berries are very large; uniform ovoid elongated, almost pointed; bright greenish to greenish white, often with a pink blush; neutral in flavor; low in acid; firm and tender; thin-skinned, easily bruised, and inclined to discolor where bruised. The stems are somewhat brittle. The vines are very vigorous and productive if cane-pruned. The fruit ripens in midseason.

The Olivette blanche does well in all grape-growing areas of the San Joaquin and intermediate central valley regions.

TABLE 3

LESS-KNOWN TABLE-GRAPE VARIETIES

Variety	Period of maturity	Color of berry	Size of berry	Shape of berry	Special characteristics
Black Hamburg	Medium	Black	Large	Spherical	.....
Black Prince	Medium	Black	Large	Spherical	Crisp texture
Chasselas doré	Early	White	Medium	Spherical	.....
Chasselas rose	Early	Red	Medium	Spherical	.....
Damas rose	Medium	Red	Very large	Spherical	Soft texture
Danugue	Late	Black	Large	Spherical	Very large clusters
Dattier	Medium	White	Large	Ellipsoidal	.....
Ferrara	Late	Reddish black	Large	Ellipsoidal	Good keeping qualities
Flame Muscat	Medium	Pink	Large	Obovoid	Muscat flavor
Gros Colman	Medium	Black	Very large	Spherical	.....
Italia	Medium	White	Very large	Ellipsoidal	Muscat flavor
Khandahar	Medium	White	Very large	Cylindroidal	Brittle stems
Milton	Late	Black	Large	Spherical	Good keeping qualities
Monukka	Medium	Reddish black	Medium	Ellipsoidal	Seedlessness
Muscat Hamburg	Medium	Black	Medium	Ellipsoidal	Muscat flavor
Pearl of Csaba	Very early	White	Medium	Spherical	Muscat flavor
Prune de Cazouls	Late	Black	Large	Ovoid	Tough skins
Sultanina rose	Medium	Pink	Medium	Ellipsoidal	Seedlessness

Rish Baba.—The beautiful appearance and odd shape of the Rish Baba, a variety of Persian origin, has given it about the same importance as the Olivette blanche. Both have been indiscriminately marketed as "Lady Fingers." Both have essentially the same merits and defects.

The clusters are medium in size; long cylindrical; very loose. The berries are large; much elongated, with one side nearly straight, the other bulged near the middle, and the ends rounded; pale greenish white to light yellow; neutral in flavor; very low in acid; very tender; and are thin-skinned and easily bruised. The stems are brittle. The vines are vigorous, and moderately productive when cane-pruned. The fruit ripens in midseason.

The Rish Baba does best in the intermediate central valley region.

"American" Varieties.—Certain of these varieties having the labrusca, or "foxy," flavor are much desired by former residents of the New England and middle western states where such grapes are common. Some can be grown fairly satisfactorily in the cooler parts of the California coastal valleys and mountain areas. Even in favored locations the quality of fruit obtained is inferior to that of the same varieties produced in good locations in the East and the Middle West. Their usefulness in California is limited to home gardens and local markets.

Wherever grown they should be trellised, cane-pruned, and irrigated frequently. Being more resistant to powdery mildew than the vinifera grapes, they need be sulfured usually only once or twice each season, often not at all. Otherwise their culture and care is the same as for vinifera varieties.

The best for California planting are as follows: black—Concord and Pierce; red—Agawam, Iona, Vergennes, Delaware, and Catawba; white—Niagara and Golden Muscat.

Table-Grape Varieties of Minor Importance.—Of the many other known varieties of table grapes, those listed in table 3, while generally not considered good shipping varieties, do possess qualities that make them suited to home gardens and local markets.

BLACK WINE GRAPES[25]

Zinfandel.—In acreage and total production the Zinfandel is the leading wine-grape variety of California. It is of unknown origin and is not grown extensively in any other country. The wine, which has a characteristic flavor, is of medium acidity and color. The variety is best suited to the cooler districts for the production of dry wines. In the hotter districts it sunburns badly and, particularly in irrigated vineyards, it is very susceptible to bunch rot.

The clusters are medium-sized; winged cylindrical; and well filled to very compact. The berries are medium-sized; spherical; reddish black to black; juicy in texture. The apical scar is irregularly shaped and slightly depressed. The grapes ripen in early midseason. The vines are moderately vigorous and very productive. Head pruning is recommended.

The Zinfandel, though best adapted to the coastal valleys, is also grown extensively in the intermediate central valley region. The best dry wines of this variety are made from grapes grown in the cooler regions.

Carignane.—Although of Spanish origin, the Carignane has been grown in the south of France probably since the twelfth century. There, and in Algeria, it is one of the most important varieties. On fertile soils it yields very large crops. It is most useful in California for the making of bulk red wines. Carignane wines are of medium acidity and color but have usually no striking varietal characteristic. Being very susceptible to powdery mildew, this grape should not be planted where control of this disease is difficult, as in locations subject to frequent summer fogs.

The clusters are medium-sized; shouldered cylindrical; well filled to compact. The berries are medium-sized; ellipsoidal; and black with a heavy blue-gray bloom. They ripen in late midseason. The vines are very vigorous and very productive. The canes are large, semierect to erect in habit of growth. Head pruning is recommended.

The Carignane, though extensively grown in nearly all wine-producing districts of the state except the coolest, is best adapted to fertile soils in the warmer parts of the coastal valleys and in the intermediate central valley region. It is not well suited to the hot districts of the San Joaquin Valley.

[25] For technical descriptions of certain black wine-grape varieties, with photographs, see: Perelli-Minetti, Joseph. Black juice-grape varieties in California. 80 p. Issued by the California Federal-State Inspection Service, Fruits and Vegetables. California Department of Agriculture in coöperation with the U. S. Department of Agriculture Bureau of Agricultural Economics. Sacramento, California. 1929.

Alicante Bouschet.—In 1865, Henri Bouschet produced the Alicante Bouschet in France by crossing Grenache with Petit Bouschet. The latter is itself a hybrid, produced by Louis Bouschet in 1829 by crossing Aramon with Teinturier. The Grand noir is another one of Louis Bouschet's hybrids. All three of these varieties have red or pink juice and are planted in California, but only the Alicante Bouschet is grown extensively. Wines made from it have no outstanding character of merit. The color, especially in new wines, is intense but fades with age; the acidity is low. In fertile soils the variety is very productive, and it is used particularly for blending with other varieties that may be deficient in color. As the grapes have fair shipping qualities, many are sent to eastern markets.

The clusters are medium-sized; shouldered conical; and well filled to compact. The berries are medium-sized; spherical; brilliant black with a blue-gray bloom. They ripen in late midseason.

The Alicante Bouschet is suited best to fertile soils in the warmer parts of the coastal valleys and in the intermediate central valley region. Additional plantings in California are not recommended.

Petite Sirah.—In suitable locations this variety, of obscure origin, yields well and is valuable for dry red wine. Wines properly made from it are of good quality, with a distinctive, recognizable flavor and moderate acidity. The skins have an abundance of color which is stable. In hot regions or hot seasons the fruit may sunburn badly.

The clusters are medium-sized; winged, cylindrical; and compact. The berries are medium-sized; slightly ellipsoidal; and black with a dull bluish-gray bloom. They ripen in early midseason. The vines are of moderate vigor and productivity. On dry hillside soils, short spur pruning is satisfactory; but in fertile soils, short cane pruning may be needed.

The Petite Sirah is best adapted to the valleys of the north coast region, where, in moderately cool locations, good dry wines may be made from it.

Mataro.—Like the Carignane, the Mataro is of Spanish origin and is of value in California primarily for the producing of bulk wines. Mataro wines lack striking varietal characteristics and have medium acidity and color. In most locations the Carignane is preferred because of its greater vigor and higher productivity. The Mataro is less susceptible to powdery mildew than the Carignane, however, and also starts its buds slightly later in the spring, a characteristic that may be important in locations subject to spring frosts.

The clusters are medium large; usually two-shouldered, conical; and compact. The berries are medium-sized; spherical; black with a heavy blue bloom; and firm pulpy. They ripen in late midseason. The vines are moderately vigorous; erect in growth; moderately productive.

The Mataro appears adapted to the south coast region and to the low foothill districts on the east side of the lower Sacramento Valley. It should not be planted in the cooler districts.

Cabernet Sauvignon.—The famous claret wines of the Gironde region of France derive their flavor and character from the Cabernet Sauvignon. In suitable locations in California it produces a wine of pronounced varietal flavor, high acidity, and good color. It is one of the finest dry-red wine varieties in California.

The clusters are small to medium in size, irregular in shape but often long conical. They are loose to well filled. The berries are small; very seedy; nearly spherical; and black with a gray bloom. They ripen in midseason. The skin is tough; the flavor rather pronounced and characteristic. The vines are very vigorous and productive with cane pruning. For satisfactory crops in most situations, long spur or cane pruning is required.

The variety is best adapted to the cooler parts of the coastal valleys, where the grapes attain their highest quality.

Grenache.—The Spanish variety Grenache is grown in California largely for the production of port-type wine, to which it is well suited. It thrives in the hot regions, bearing excellent crops. Its wines are medium low in acidity. In many locations the grapes are somewhat deficient in color and must be blended with other varieties that have more abundant color. The vines are very susceptible to powdery mildew.

The clusters are medium-sized; short conical, sometimes shouldered or winged; and loose to well filled. The berries are small medium; short ellipsoidal, nearly spherical; and reddish purple to black. They ripen in late midseason. The stems of the clusters are very thick. The vines are unusually vigorous, erect in habit of growth, and very productive, even when head-pruned.

The Grenache is probably best adapted to the hot regions, such as the San Joaquin and Sacramento valleys, which produce the dessert wines. It may deserve further trial as a constituent for dry wines in some of the coastal valleys.

Mission.—The Jesuit missionaries planted the first vinifera grapes in California at the San Diego Mission in the latter part of the eighteenth century. The variety was apparently the Mission, which, until about 1870, was the principal variety grown in California. Since then it has been gradually displaced by other varieties in the coastal regions and is now grown mainly in the warmer valleys, where it is valuable as a dessert-wine grape. It has always been associated with the making of sweet white wines, such as Angelica. It is low in acidity and too deficient in color to be used alone for red wines.

The clusters are large; conical, but heavily shouldered; and stiffly loose—stems sufficiently rigid to cause the individual berries to stand apart. The berries are medium-sized; spherical; reddish purple to black; and ripen in late midseason. The pulp is firm but juicy. The vines are very vigorous, and single vines occasionally attain enormous size. Given room to develop, the Mission bears heavily; but if it is crowded or pruned too short, the crops tend to be irregular.

This variety is adapted to all parts of the great central valley and the south coast region.

Black Malvoisie (*Cinsaut*).—The heavy-producing variety Malvoisie appears to have been imported from the south of France. It is used in California principally for blending with other varieties in making dessert wines. The grapes are low in acidity, low medium in color, and attain a very high sugar content before starting to raisin.

The clusters are medium-sized; winged cylindrical; and loose to well filled. The berries are medium large; ellipsoidal; reddish black to black. Since they

ripen in early midseason and lose water rapidly after removal from the vine, they soon become soft after picking. The vines are vigorous and productive.

Barbera.—The extremely high acid content of the Italian variety Barbera makes it unusually valuable for blending with other grapes that tend to be low in acid but are otherwise desirable. Used alone it makes a high-acid wine of considerable character, which ages slowly.

TABLE 4

IMPORTANT RED-WINE GRAPE VARIETIES NOT EXTENSIVELY GROWN IN CALIFORNIA*

Variety	Period of maturity	Acidity	Intensity of color	Productivity	Kind of wine usually produced
Aleatico	Early	Medium	Low	Medium	Dessert, muscat
Alicante Ganzin	Medium	Medium	Very high	Medium	Blending, color
Aramon	Late	Medium	Low	High	Dry, table
Beclan	Medium	Low	Medium	Low	Dry, table
Black Prince	Medium	Low	Low	High	Dessert
Charbono	Late	Medium	High	Medium	Dry, table
Fresia	Early	High	Medium	Low	Dry, varietal
Grand noir	Medium	Medium	High	Medium	Dry, table
Grignolino	Early	High	Low	Medium	Dry, varietal
Gros Manzenc	Late	High	High	Medium	Dry, table
Lagrain	Early	Medium	High	Medium	Dry, table
Malbec	Early	Medium	Medium	Medium	Dry, table
Mondeuse	Late	Medium	High	Medium	Dry, table
Mourisco preto	Medium	Medium	Medium	Medium	Dessert
Nebbiolo	Medium	High	Medium	Medium	Dry, table
Pagadebito	Late	Medium	High	Medium	Dry, table
Petit Bouschet	Medium	Low	High	Medium	Dry, table
Pinot noir	Early	High	Medium	Low	Dry, varietal
Refosco	Medium	Medium	High	Medium	Dry, table
Saint Macaire	Medium	Medium	High	Medium	Dry, table
Salvador	Early	High	Very high	Low	Blending, color
Sangioveto	Medium	High	Medium	Medium	Dry, table
Tannat	Early	High	High	Medium	Dry, varietal
Tinta amarella	Medium	Low	Medium	Medium	Dessert
Tinta de Madeira	Early	Low	Medium	Medium	Dessert
Trousseau	Early	Low	Low	High	Dessert
Valdepeñas	Early	Medium	Medium	High	Dry, table

* The values assigned are only relative and will vary with environmental conditions. In the right-hand column, *table* refers to a wine of no particular recognizable varietal characteristic: no other indication of quality is intended. *Varietal* refers to a wine having a particular flavor or other character recognizable as having been imparted to the wine by the particular variety of grapes.

The clusters are medium in size; conical; winged, well filled. The berries are medium-sized; ellipsoidal; black, with abundant color in the skin; neutral in flavor, astringent, and high in acid content. They ripen in midseason. The vines are vigorous and productive with head pruning.

The Barbera is best suited to the warm areas of the coastal valleys and the intermediate central valley region.

Other Red-Wine Grapes.—Many of the world's most important red-wine grape varieties are not included in the foregoing descriptions because they are not grown extensively in California. Very brief notes on certain of them are given in table 4.

WHITE-WINE GRAPES

Palomino.—In some parts of California the Palomino is erroneously called Golden Chasselas. It is said to be the principal sherry grape of Jerez (Spain). Widely adaptable to various soils and climates, it thrives in nearly all warm,

wine-grape-producing districts of the state. It is particularly well suited to sherry production, but makes an inferior dry wine.

The clusters are large medium in size; shouldered and widely branched; stiffly loose to well filled. The berries are medium; oblate; greenish yellow, with a heavy white bloom; and firm to somewhat tough. They ripen in late midseason. The vines are very vigorous and very productive. The leaves are dull, dark bluish green in color, rough on the upper surface, with a heavy, tufted pubescence on the lower surface. Either head or cordon pruning is satisfactory.

The Palomino is particularly well suited to the San Joaquin, Sacramento, and intermediate central valley regions. It also does well in the warm parts of the coastal valleys, but not in the cool areas.

Burger.—Where the soil is fertile and the climate warm, the Burger produces enormous crops. In cool locations it does not ripen well, and early rains may cause much damage from bunch rot. In the warmer parts of the coastal valleys, the berries produce a light wine of fair quality. In the south coast and the intermediate central valley regions, the Burger ripens better and gives heavier yields. Its primary usefulness is in bulk wines. When the vines are overcropped, the grapes are low in acidity.

The clusters are large medium in size; shouldered to winged cylindrical; and compact. The berries are medium-sized; spherical; whitish yellow; very juicy; soft; late ripening. The vines are vigorous and highly productive even with head pruning.

The Burger is best suited to warm locations in the coastal valleys and to the intermediate central valley region.

Sauvignon Vert.—The origin and true name of the variety grown in California under this name is obscure. It is not the Sauvignon vert of France, but it may be the variety grown there as Muscadelle du Bordelais and used to a limited extent for blending with Semillon in making the wines of the Sauternes. Its wine has moderate varietal flavor and aroma, but is low in acid, is harsh, and does not keep well. In frosty locations the Sauvignon vert often bears better than many other varieties.

The clusters are small to medium; cylindrical; loose to compact. The berries are small medium; short ellipsoidal; greenish yellow; soft in texture; juicy; and thin-skinned. They ripen in midseason. The vines are vigorous, semi-upright in habit of growth, and very productive.

The Sauvignon vert is best suited to the valleys of the north coast region.

Semillon.—The world-famous Sauterne wines of France largely owe their character to the Semillon grapes. This variety, one of the truly fine wine grapes of the world, does very well in certain parts of California. Here, however, because of the dryness of the climate, the "noble rot" (*Botrytis cinerea*) does not work on the grapes as they ripen; hence the finished wines differ from the French sauternes in flavor and aroma.

The clusters are small to medium in size; short conical; well filled. The berries are medium-sized; spherical; golden yellow; sprightly and aromatic in flavor. They ripen in early midseason. The vines are vigorous and moderately productive.

The Semillon is best suited to the north coast region.

Sauvignon Blanc.—Next to the Semillon the Sauvignon blanc is the most important variety of the sauternes. Used alone, it makes a fine wine of pronounced character; but the blend with Semillon is usually considered superior to the wine of either variety used alone.

The clusters are small to very small; conical; and very loose. The berries are small; spherical; whitish yellow; they ripen in early midseason. The vines, though vigorous, are usually shy bearing unless cane-pruned.

The Sauvignon blanc is best suited to the north coast region.

Johannisberger Riesling (White Riesling).—The Rhine wines of Germany are made principally from the Johannisberger Riesling. Its wines possess a strong varietal flavor and bouquet, and the other constituents harmonize.

The clusters are small; cylindrical; well filled. The berries are small medium in size; spherical; greenish yellow, speckled with brown russet dots; sprightly, somewhat aromatic in flavor; and juicy. They ripen in early midseason. The vines are vigorous and moderately productive with cane pruning.

This variety is suited only to cool areas of the north coast region.

Franken Riesling (Sylvaner).—The Franken Riesling, the principal Rhine-wine type grown in California, endures more warmth than the Johannisberger. The wine is of good character.

The clusters are shouldered conical and compact; the berries whitish yellow. Otherwise the grapes closely resemble the Johannisberger in appearance.

The variety is suited only to the north coast region.

Green Hungarian.—The vines of the Green Hungarian are very vigorous and very productive. The variety produces a light, neutral wine which lacks character and is suited best for blending in the making of cheap bulk wines.

The clusters are large; shouldered cylindrical; and compact. The berries are medium to large; spherical; light green; and soft juicy in texture. They ripen in midseason.

This variety is adapted to the intermediate central valley region and the warm coastal valleys.

Folle Blanche.—In white wines requiring a high-acid content, such as champagne, the Folle Blanche is particularly valuable for blending purposes.

The clusters are small medium in size; conical, shouldered or winged; and compact. The berries are small medium; spherical or short ellipsoidal; whitish or yellowish green; soft; neutral in flavor, and high in acid. They ripen in midseason. The vines are moderately vigorous and productive with head pruning.

The Folle blanche is best suited to the warm or moderately cool areas of the coastal valleys.

French Colombard.—A combination of high productivity of the vines and high acid content of the grapes gives the French Colombard a place in the moderately warm areas of the state for producing standard-quality dry wines. Before prohibition the French Colombard was rather widely grown under the name of West's White Prolific.

The clusters are medium in size; long conical; well filled. The berries are medium-sized; ellipsoidal; yellowish green, sometimes with a pink tinge; neutral in flavor, and high in acid. They ripen in midseason. The vines are very vigorous and very productive with head pruning.

The French Colombard is best suited to the warm areas of the coastal valleys and the intermediate central valley region.

Other White-Wine Grapes.—Certain additional varieties of white-wine grapes, important in other countries but not extensively grown in California, are given in table 5.

TABLE 5

IMPORTANT WHITE-WINE GRAPE VARIETIES NOT EXTENSIVELY GROWN IN CALIFORNIA*

Variety	Period of maturity	Acidity	Productivity	Kind of wine usually produced
Boal de Madeira	Medium	Medium	High	Dessert
Chardonnay	Early	Medium	Low	Dry, varietal
Chasselas doré	Early	Low	Medium	Dry, table
Clairette blanche	Medium	Medium	High	Dry, table
Feher Szagos	Late	Low	Very high	Sherry
Gray Riesling	Medium	Medium	High	Dry, table
Inzolia	Late	Low	High	Dessert
Kleinberger	Medium	Medium	Medium	Dry, table
Muscat Canelli	Early	Medium	Low	Dessert, varietal
Peverella	Medium	Medium	Medium	Dry, table
Pinot blanc	Early	High	Medium	Dry, varietal
Saint Emilion	Late	Medium	Medium	Dry, table
Vernaccia Sarda	Medium	Medium	High	Dessert

* The values assigned are relative only and will vary with environmental conditions. In the right-hand column, *table* refers to a wine of no particular recognizable varietal characteristic; no other indication of quality is intended. *Varietal* refers to a wine having a particular flavor or other character recognizable as having been imparted to the wine by the particular variety of grapes.

A discussion of the use of grapes in the making of wine is outside the province of this circular. For information concerning wines the reader is referred to Bulletin 639—Commercial production of table wines—and Bulletin 651—Commercial production of dessert wines. Information on the making of brandies can be obtained from Bulletin 652—Commercial production of brandies.

New Plantings.—High prices since 1942 have stimulated an interest in new grape plantings unequaled since the planting spree of the early 1920's. Ruinously low prices followed that former expansion. Unwarranted expansion of the vineyard acreage now will certainly bring on a similar disaster. The world acreage of raisin-variety grapes is the highest in history, and there seems to be no good reason to expect that the market for California raisins in the foreseeable future will exceed that of prewar years. New plantings of raisin grapes should therefore be not greater than is needed to replace over-age vineyards that are uprooted. The over-all production of table grapes also appears to be entirely adequate to supply the anticipated demands of the near future, once the markets become stable.

Acreage shifts among varieties and localities may be expected, but are not predictable; certainly no over-all expansion appears to be in order. The phenomenally high wine-grape prices of 1946 were largely the result of the shortage of grain supplies to distillers—a temporary situation. Common wine-variety-grape production appears adequate to supply the probable demand when the distillers are again able to secure all the grain they want. Good wine varieties should continue in demand beyond present supply. These include such varieties as Cabernet Sauvignon, Gamay Beaujolais, Semillon, Sauvignon blanc, Pinot blanc, Sylvaner, and White Riesling for the coastal valleys; and Palomino, Grenache, and Mission for the interior valleys.

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